Geo Schott M.D

THE

INTERNATIONAL ENCYCLOPÆDIA

OF

SURGERY.

VOL. I.

THE

Geo Schott M.D.
Vermillion
Dak

INTERNATIONAL ENCYCLOPÆDIA

OF

SURGERY

A SYSTEMATIC TREATISE

ON THE

THEORY AND PRACTICE OF SURGERY

BY

AUTHORS OF VARIOUS NATIONS

EDITED BY
JOHN ASHHURST, JR., M.D.
PROFESSOR OF CLINICAL SURGERY IN THE UNIVERSITY OF PENNSYLVANIA

ILLUSTRATED WITH CHROMO-LITHOGRAPHS AND WOOD-CUTS

IN SIX VOLUMES

VOL. I.

NEW YORK
WILLIAM WOOD & COMPANY
1881

COLLINS, PRINTER.

PREFACE.

The object of this work is to furnish, in a comprehensive and yet not unduly extended form, a Systematic and Practical Treatise upon all those subjects which are properly considered to pertain to the Science and Art of Surgery, the various topics discussed in the several volumes having been intrusted to distinguished writers of various countries, who are believed to be specially qualified to give authoritative instruction, each upon the particular subject which he has undertaken.

The general plan of the work is as follows:—

In the First Volume are embraced such subjects as may be looked upon as belonging to General Surgery, including Inflammation, regarded both from the position of the Pathological Histologist, and from that of the Clinical Observer and Practical Surgeon; Erysipelas and Pyæmia; Hydrophobia and Glanders; Scrofula and Tubercle; Rachitis, and Scurvy. Articles follow upon the Reciprocal Effects of Constitutional Conditions and Injuries; upon the General Principles of Surgical Diagnosis; upon Operative Surgery in General; upon Plastic and upon Minor Surgery; upon the use of Anæsthetics; upon Shock; upon Traumatic Delirium and Delirium Tremens; and upon Amputations.

In the Second Volume will be begun the study of Special Surgery, those affections being first considered which, though local in themselves, may yet be met with in any part of the body. The Volume will also contain articles upon the several varieties of Venereal Disease, and will begin the discussion of Injuries and Diseases of the Various Tissues of the body.

The Third and Fourth Volumes will conclude the Surgery of the Tissues, and the latter will also begin the consideration of Injuries and Diseases of Special Regions.

Regional Surgery will be continued through the Fifth and Sixth Volumes, and the last will contain, in addition, a History of Surgery, which (his health permitting) has been promised by Professor Gross.

An Appendix will embrace papers on Hospital Construction, and similar important topics of collateral interest to Surgical Science; and a full Analytical Index will, in connection with the Table of Contents and Subject Index in each Volume, serve to facilitate reference to every part of the work.

For the plan of the Encyclopædia, the arrangement of the material, and the general supervision of the whole, the Editor is responsible, as he is also for those Articles which bear his own name (in the present volume, the Article on Amputations), and for a few notes, chiefly in regard to practical matters, which may be distinguished by their being included within brackets [thus]. But for the facts and opinions in the various Articles, with the exceptions named, the entire responsibility rests with the individual authors. In a work of this character, some repetition is unavoidable, inasmuch as the subjects of the several Articles necessarily overlap each other in many instances; but this very circumstance is rather of advantage than otherwise, as enabling the reader to compare the independent views, upon questions of importance, entertained by different writers of equal eminence.

In regard to the illustrations which accompany the work, it has been the aim of both the Editor and Publishers to supply whatever might be really serviceable in rendering the text more clear, while at the same time introducing none which were not truly illustrative. For some subjects, a large number are required, while for others, the use of any illustrations would be of at least doubtful value. In accordance with the Publishers' preference, the plates and almost all of the wood-cuts (except some of instruments, etc.) are original, and have been executed

expressly for this work, either from photographs or from drawings, many of which are from the skilful pencil of the Editor's friend and former pupil, Dr. J. Madison Taylor.

The Editor desires to offer his sincere thanks to the many distinguished surgeons and physicians, who—in several instances, at the cost of great personal inconvenience—have given him their aid as collaborators, and without whose valued assistance the production of the Encyclopædia would have been impossible. His thanks are also due for important help of various kinds, rendered by Dr. W. M. Carpenter, of New York, and by Dr. H. R. Wharton and Dr. F. C. Sheppard, of Philadelphia.

JOHN ASHHURST, Jr.

Philadelphia,
2000 West Delancey Place,
November, 1881.

ALPHABETICAL LIST OF AUTHORS.

(VOL. I.)

D. HAYES AGNEW,
JOHN ASHHURST, Jr.,
JOHN H. BRINTON,
HENRY TRENTHAM BUTLIN,
FRANCIS DELAFIELD,
WILLIAM S. FORBES,
WILLIAM HUNT,
CHARLES T. HUNTER,
CHRISTOPHER JOHNSTON,
HENRY M. LYMAN,
C. W. MANSELL-MOULLIN,
J. LEWIS SMITH,
ALFRED STILLÉ,
S. STRICKER,
WILLIAM H. VAN BUREN,
A. VERNEUIL,
PHILIP S. WALES.

THE INTERNATIONAL

ENCYCLOPÆDIA OF SURGERY.

ARTICLES CONTAINED IN THE FIRST VOLUME.

DISTURBANCES OF NUTRITION; THE PATHOLOGY OF INFLAMMATION. By S. STRICKER, M.D., Professor of Experimental and General Pathology in the University of Vienna. Page 1.

INFLAMMATION. By WILLIAM H. VAN BUREN, M.D., LL.D., Professor of the Principles and Practice of Surgery in the Bellevue Hospital Medical College, New York. Page 65.

ERYSIPELAS. By ALFRED STILLÉ, M.D., LL.D., Professor of the Theory and Practice of Medicine and of Clinical Medicine in the University of Pennsylvania, Philadelphia. Page 161.

PYÆMIA AND ALLIED CONDITIONS. By FRANCIS DELAFIELD, M.D., Adjunct Professor of Pathology and Practical Medicine in the College of Physicians and Surgeons, Medical Department of Columbia College, New York. Page 203.

HYDROPHOBIA AND RABIES. GLANDERS. MALIGNANT PUSTULE. By W. S. FORBES, M.D., Demonstrator of Anatomy in the Jefferson Medical College, Senior Surgeon to the Episcopal Hospital, Philadelphia. Page 215.

SCROFULA AND TUBERCLE. By HENRY TRENTHAM BUTLIN, F.R.C.S., Assistant Surgeon to, and Demonstrator of Surgery at, St. Bartholomew's Hospital, London. Page 231.

RACHITIS. By J. LEWIS SMITH, M.D., Clinical Professor of Diseases of Children in the Bellevue Hospital Medical College, New York. Page 251.

SCURVY. By PHILIP S. WALES, M.D., Surgeon-General of the United States Navy. Page 277.

THE RECIPROCAL EFFECTS OF CONSTITUTIONAL CONDITIONS AND INJURIES. By A. VERNEUIL, M.D., Professor of Clinical Surgery in the Faculty of Medicine, Paris. Page 307.

GENERAL PRINCIPLES OF SURGICAL DIAGNOSIS. By D. HAYES AGNEW, M.D., LL.D., Barton Professor of Surgery in the University of Pennsylvania, Surgeon to the Pennsylvania Hospital, Philadelphia. Page 337.

SHOCK. By C. W. MANSELL-MOULLIN, M.A., M.D. OXON., F.R.C.S., Fellow of Pembroke College, Oxford; Late Travelling Fellow, Univ. Oxon.; Surgical Registrar to the London Hospital, London. Page 357.

TRAUMATIC DELIRIUM AND DELIRIUM TREMENS. By WILLIAM HUNT, M.D., Senior Surgeon to the Pennsylvania Hospital, Philadelphia. Page 379.

ANÆSTHETICS AND ANÆSTHESIA. By HENRY M. LYMAN, A.M., M.D., Professor of Physiology and of Diseases of the Nervous System in the Rush Medical College, Chicago. Page 403.

OPERATIVE SURGERY IN GENERAL. By JOHN H. BRINTON, M.D., Lecturer on Operative Surgery in the Jefferson Medical College and Surgeon to the Jefferson Medical College Hospital, Surgeon to the Philadelphia Hospital, and to St. Joseph's Hospital, Philadelphia. Page 435.

MINOR SURGERY. By CHARLES T. HUNTER, M.D., Demonstrator of Anatomy in the University of Pennsylvania, Surgeon to the Episcopal Hospital, Philadelphia. Page 479.

PLASTIC SURGERY. By CHRISTOPHER JOHNSTON, M.D., Emeritus Professor of Surgery in the University of Maryland, Baltimore. Page 531.

AMPUTATIONS. By JOHN ASHHURST, Jr., M.D., Professor of Clinical Surgery in the University of Pennsylvania, Philadelphia. Page 551.

CONTENTS.

	PAGE
PREFACE	v
ALPHABETICAL LIST OF AUTHORS IN VOL. I.	viii
LIST OF ARTICLES IN VOL. I.	ix
LIST OF ILLUSTRATIONS	xxxvi

DISTURBANCES OF NUTRITION; THE PATHOLOGY OF INFLAMMATION.

BY

S. STRICKER, M.D.,

PROFESSOR OF EXPERIMENTAL AND GENERAL PATHOLOGY IN THE UNIVERSITY OF VIENNA.

(TRANSLATED BY ALFRED MEYER, M.D., OF NEW YORK.)

Hyperæmia	1
Active hyperæmia	2
Passive hyperæmia	3
Anæmia and ischæmia	3
Causes of hyperæmia and ischæmia	4
Contractile elements of bloodvessels	4
Contractility of the capillaries	5
Contractility of the capillaries compared to the contractility of the cells of glands	9
The vaso-motor nerves	11
Hyperæmia of irritation and paralysis	18
The mechanical hyperæmias	19
Consequences of hyperæmia ; œdema and hemorrhage	20
Cardinal symptoms of inflammation	23
General remarks concerning the inflammatory changes of tissues	24
Historical remarks concerning the theory of inflammation	25
Virchow's suppuration-theory	25
Cohnheim's migration-theory	25
Doctrine of the tissue-metamorphosis	27
Suppurative keratitis	28
Paths for nutrition and spaces for collection of œdema	33
Apparent migration of cells in the midst of tissue and vital processes in the basis-substance	34

PAGE

Suppurative inflammation in tendon, cutis, bone, cartilage, and other connective substances 37
Tendon 37
Cutis 38
Bone 38
Cartilage 38
Theory of fibrillæ and of connective substance 41
On the cell-nucleus 42
Comparison between the supposed fibrillar substances and the other connective substances 43
The transversely striped muscular fibres; continuation of the discussion on the nature of the fibrillæ 44
The smooth muscular fibres and the central nervous system; continuation of the discussion, etc. 47
Smooth muscular fibres 47
White and gray matter of the central nervous system . . . 47
Suppuration of the spinal cord 48
New observations on the supposed fixed cells. Conclusion of the discussion on the nature of the fibrillæ 51
Epithelium and endothelium 55
Endothelium 55
Epithelium 56
Healing by first intention and healing by granulation 57
Transplantation of cutis 58
Regeneration 59
Non-inflammatory new formations 60
Degeneration of the tissues 61
Fatty degeneration 61
Amyloid degeneration 62
Calcareous degeneration 62
Colloid degeneration 62

INFLAMMATION.

By

WILLIAM H. VAN BUREN, M.D., LL.D.,

PROFESSOR OF THE PRINCIPLES AND PRACTICE OF SURGERY IN THE BELLEVUE HOSPITAL MEDICAL COLLEGE, NEW YORK.

General considerations regarding inflammation. Definitions . . . 65
Causes of inflammation 68
Irritation and injury 68
Classification of causes 68
Predisposing causes 70
Defect in quality of blood 70
Presence of poison in blood 71

PAGE

Causes of inflammation—
Defective or deranged nervous supply 71
Period of life 72
Habit of body, etc. 73
Habitual functional hyperæmia 73
Climate, etc. 73
Exciting causes 74
Cold and sudden chilling 74
Incised wounds 75
Punctured wounds 76
Presence of foreign material in wounds 76
Mechanical violence, wrenching, straining, etc. . . . 78
Contusion 78
Presence of a clot of blood 79
Persistent mechanical action 80
Action of chemical irritants 80
Heat 80
Poisonous action of minerals 81
Poisonous action of plants 82
Poisonous secretions of animals 82
Venom of serpents 84
Parasites 85
Microscopic fungi 85
Putrid substances 90
Modes in which poisons are absorbed 92
Symptoms of inflammation 95
Redness 96
Heat 97
Swelling 97
Pain 98
Impairment or abolition of function 99
Traumatic or inflammatory fever 99
Phenomena of traumatic fever 100
Nature of fever 102
Causes of surgical fever 103
Infective and non-infective inflammation and fever . . . 105
Blood-poisoning, septicæmia, and pyæmia 106
Inflammatory exudations 106
Passive and active exudation; œdema 107
Exudation of plastic lymph 108
Croupous exudation 109
Plastic or coagulable lymph 110
Union by first intention 111
Healing under a scab 111
Destructive inflammation. Pus formation 112
Suppuration and granulation 112
Union by secondary adhesion 114
Physical qualities of pus 114

PAGE

Destructive inflammation—
- Anatomical characteristics of pus 115
- Liquid portion of pus 116
- Sources of pus 116
  - Abscess 117
  - Formation of pus on serous and mucous membranes . . . 119
- Phenomena attending pus formation 119

Ulceration 120
Gangrene 121
Significance of suppuration 122
- Significance of odors from pus 122
- Poisonous qualities of pus 123
- Pus involves waste of tissue 124
- Uses of pus 124

Varieties of pus 125
Substances mistaken for pus 126
Injurious consequences of suppuration 126
Purulent infiltration with connective-tissue necrosis 127
Hectic fever 129
Chronic inflammation 130
- Induration 131
- Hyperplasia and hypertrophy 131

Catarrhal inflammation 132
Inflammation in the scrofulous 133
Inflammation in the syphilitic 134
Terminations of inflammation 135
- Resolution 136
- Tissue production 136
- Gangrene 137

Treatment of inflammation 138
  - Prevention 138
  - Detection and removal of causes 139
  - Insurance of favorable conditions 139
  - Mitigation and control of manifestations 140
- Prevention 140
- Rest and immobility 142
- Position 144
- Cold 144
  - Irrigation 145
- Heat and moisture 146
- Compression 147
- Blood-letting 149
- Incisions 151
- Drainage 152
- Revulsion and counter-irritation 153
  - Derivation by ligation of main artery 154
- Diet and nursing 154
  - Diet 154

PAGE

Treatment of inflammation—
Stimulus 155
Nursing 155
Medicines employed in treating inflammation 155
Anodynes 156
Quinine 156
Mercury 156
Astringents 157
Laxatives and cathartics 157
Depressants 158
Antiseptics 159

ERYSIPELAS.

By

ALFRED STILLÉ, M.D., LLD.,

PROFESSOR OF THE THEORY AND PRACTICE OF MEDICINE AND OF CLINICAL MEDICINE IN THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA.

Synonyms and derivation of name 161
History of erysipelas 161
Causes of erysipelas 162
Sex and age 162
Cold 163
Cachectic conditions 163
Sewer gas, etc. 164
Contagion 165
Specific cause of erysipelas 167
Causes of erysipelas as illustrated by the history of epidemic outbreaks of the disease 168
Cases illustrating unity of various types 170
Connection of epidemic erysipelas with puerperal fever . . . 173
Morbid anatomy of erysipelas 176
Symptoms of erysipelas 177
Wandering erysipelas 178
Temperature in erysipelas 179
Phlegmonous erysipelas 182
Œdematous erysipelas 183
Gangrenous erysipelas 183
Erysipelas of face and scalp 184
Bilious erysipelas 186
Metastatic erysipelas 186
Erysipelas of new-born infants 186
Erysipelatous peritonitis 187
Diagnosis of erysipelas 188
Prognosis of erysipelas 188

PAGE
Prophylaxis of erysipelas 190
Treatment of erysipelas 191
Views of the ancients 191
Trousseau's view 192
Blood-letting 193
Cold 194
Astringents and stimulants 194
Nitrate of silver, iodine, etc. 195
Surgical treatment 195
Punctures and incisions 196
Carbolic acid 197
Internal treatment 197
Purgatives and emetics 197
Alcoholic stimulants, etc. 198
Quinia 198
Tincture of chloride of iron 199
Treatment in infants and old persons 201
Treatment of erysipelas of air-passages 201
Treatment of epidemic erysipelas 201

PYÆMIA AND ALLIED CONDITIONS.

By

FRANCIS DELAFIELD, M.D.,

ADJUNCT PROFESSOR OF PATHOLOGY AND PRACTICAL MEDICINE IN THE COLLEGE OF PHYSICIANS AND SURGEONS, MEDICAL DEPARTMENT OF COLUMBIA COLLEGE, NEW YORK.

Nomenclature of pyæmia 203
Nature of pyæmia 204
Theory of pus absorption 204
Chemical theory 204
Germ theory 205
Examination of blood and tissues 205
Experiments on animals 206
Symptoms and lesions of pyæmia 207
Mechanical and infectious emboli 211
Treatment of pyæmia 211
Prolonged suppuration 213
Spontaneous pyæmia 214

HYDROPHOBIA AND RABIES; GLANDERS; MALIGNANT PUSTULE.

By
WILLIAM S. FORBES, M.D.,
DEMONSTRATOR OF ANATOMY IN THE JEFFERSON MEDICAL COLLEGE; SENIOR SURGEON TO THE EPISCOPAL HOSPITAL, PHILADELPHIA.

	PAGE
Hydrophobia and rabies	215
Cause of hydrophobia	215
Rabies in the dog	216
Incubation of hydrophobia	217
Symptoms of hydrophobia	218
Symptoms of first stage	218
Symptoms of second stage	218
Symptoms of third stage	219
Morbid anatomy of hydrophobia	219
Diagnosis of hydrophobia	220
Prognosis of hydrophobia	221
Treatment of hydrophobia	222
Preventive treatment	222
Curative treatment	223
Glanders	225
Symptoms of glanders	225
Symptoms in the horse	225
Symptoms in man	226
Diagnosis of glanders	227
Prognosis of glanders	227
Treatment of glanders	227
Malignant pustule	228
Symptoms of malignant pustule	228
Pathology of malignant pustule	229
Treatment of malignant pustule	229

SCROFULA AND TUBERCLE.

By
HENRY TRENTHAM BUTLIN, F.R.C.S.,
ASSISTANT SURGEON TO, AND DEMONSTRATOR OF SURGERY AT, ST. BARTHOLOMEW'S HOSPITAL, LONDON.

Tubercle	231
Illustrative cases	231
Analysis of the above cases	234
Morbid anatomy of tubercle	234

	PAGE
Origin and natural history of tubercle	235
Infection of tubercle	236
Nature of tubercle	237
Pathology of tubercle	238
Treatment of tubercle	238
Scrofula	240
Illustrative cases	240
Nature of scrofula	241
Morbid anatomy of scrofula	242
Diagnosis of scrofula	242
Tissues and organs affected by scrofula	243
Relation of scrofula to tubercle	244
Modifications produced by scrofula in other diseases	245
Gonorrhœa and epididymitis	245
Syphilis	245
Gout	246
Causes and course of scrofula	246
Prognosis of scrofula	246
Treatment of scrofula	247
Constitutional treatment	247
Local treatment	248

RACHITIS.

By

J. LEWIS SMITH, M.D.,

CLINICAL PROFESSOR OF DISEASES OF CHILDREN IN THE BELLEVUE HOSPITAL MEDICAL COLLEGE, NEW YORK.

Frequency of rachitis	251
Age at which rachitis occurs	252
Fœtal rachitis	253
Causes of rachitis	254
Inheritance	254
Food	254
Artificial production of rachitis	255
Heitzmann's observations	256
Anatomical characters of rachitis	257
Stage of proliferation and altered nutrition	257
Cartilaginous changes	257
Osseous changes	258
Pathology of rachitis	259
Stage of deformity	260
Changes in cranial bones	260
Craniotabes	261
Symptoms of craniotabes	262
Connection with laryngismus stridulus	263

PAGE
Changes in vertebræ 264
Changes in maxillæ 264
Changes in ribs 265
Changes in bones of upper extremity 266
Changes in bones of pelvis 267
Changes in bones of lower extremity 267
Effect of rachitis on dentition 268
Changes in soft tissues 269
Stage of reconstruction 270
Symptoms of rachitis 270
Complications and sequelæ of rachitis 271
Diagnosis of rachitis 272
Prognosis of rachitis 273
Treatment of rachitis 274
Diet 274
Medicines 275

SCURVY.

By
PHILIP S. WALES, M.D.,
SURGEON-GENERAL OF THE UNITED STATES NAVY.

Synonyms 277
History of scurvy 277
Etiology of scurvy 285
Geographical limitation 285
Age 285
Sex 286
Low temperature 286
Depressing emotions 286
Foul air 287
Impure water 287
Individual peculiarities 287
Food supply 288
Use of salted meats 288
Deficiency in quantity and quality of food 289
Deficiency in variety of food 289
Morbid anatomy of scurvy 290
Rigor mortis 290
Skin and connective tissue 290
Periosteum 291
Joints 291
Serous membranes 291
Mouth, gums, etc. 291
Nervous system 291

	PAGE
Heart	291
Lungs	292
Stomach and bowels	292
Liver, spleen, and pancreas	292
Kidneys	292
Pathology of scurvy	293
Symptoms of scurvy	295
Scorbutic cachexia	295
Impairment of mental powers	296
Pains in limbs	296
Changes in gums	296
Extravasations of blood and œdema	297
Hemorrhages	298
Serous effusions	298
Cerebral symptoms	299
Embolism, etc.	299
Urinary symptoms	299
Splenic and hepatic symptoms	300
Ophthalmic and aural symptoms	300
Fever	300
Diagnosis of scurvy	301
Prognosis of scurvy	301
Treatment of scurvy	302
Prophylaxis	302
Curative treatment	304

THE RECIPROCAL EFFECTS OF CONSTITUTIONAL CONDITIONS AND INJURIES.

By

A. VERNEUIL, M.D.,

PROFESSOR OF CLINICAL SURGERY IN THE FACULTY OF MEDICINE, PARIS.

Classification of constitutional conditions	307
Reciprocal influence of constitutional conditions and injuries	308
Period of dyscrasia	309
Period of peripheral lesions	309
Period of visceral lesions	309
Time of operation	310
Mode of operation	310
Choice of dressing	310
Constitutional treatment	311
Arthritism	311
Rheumatism	311
Gout	312
Herpetism	313

	PAGE
Cancer	313
Scrofula	315
Tuberculosis	316
Scurvy	317
Leucocythæmia	318
Hæmophilia	318
Syphilis	319
Malaria	321
Alcoholism	322
Delirium tremens	323
Morphinism	324
Saturnism or lead-poisoning	324
Hepatism; nephrism; cardism	325
Hepatism	326
Nephrism	327
Cardism	329
Aneurism of aorta	329
Arterial atheroma	329
Locomotor ataxia and various neuroses	329
Hysteria and epilepsy	330
Insanity	330
Diabetes mellitus	330
Alcohol diabetes	331
Phosphaturia, azoturia, polyuria, etc.	331
Pregnancy	332
Rules for operations during pregnancy	334
Infancy	334
Old age	335

GENERAL PRINCIPLES OF SURGICAL DIAGNOSIS.

By

D. HAYES AGNEW, M.D., LL.D.,

BARTON PROFESSOR OF SURGERY IN THE UNIVERSITY OF PENNSYLVANIA, SURGEON TO THE PENNSYLVANIA HOSPITAL, PHILADELPHIA.

Analytical and synthetical modes of investigation	337
Difficulties in surgical diagnosis	338
General examination of a patient	339
Age	339
Sex	339
Occupation	340
Habits	340
Antecedent history	341
Personal history	341
Mental and moral states	342

	PAGE
Social condition	342
Residence	343
Duration of disease	343
Special examination ; personal investigation	343
Posture or attitude	343
External expressions of parts	343
Information derived from touch	345
Weight	345
Mobility	345
Temperature	345
Color	345
Translucency	345
Mensuration	346
Sound	346
Movements	346
Smell	347
Interrogation of internal organs	347
Circulation	347
Thermometry	348
Respiration	349
Nervous system	350
Significance of pain	351
Mobility	351
Digestive apparatus	352
Genito-urinary system	354

SHOCK.

By

C. W. MANSELL-MOULLIN, M.A., M.D. Oxon., F.R.C.S.,

FELLOW OF PEMBROKE COLLEGE, OXFORD; LATE RADCLIFFE'S TRAVELLING FELLOW, UNIV. OXON.; SURGICAL REGISTRAR TO THE LONDON HOSPITAL, LONDON.

Causes of shock	357
Mental emotion	358
Sex and age	359
Pain	359
Mental pre-occupation and expectation	359
Cases attended by shock	359
Symptoms of shock	362
Prostration with excitement	363
Pathology of shock	365
Goltz's experiments	366
Tappeiner's and Muller's experiments	367
Lewisson's experiments	369
Prognosis of shock—reaction	369

	PAGE
Treatment of shock	371
Prevention of shock	371
External heat	371
Stimulants	372
Opium	372
Artificial respiration and transfusion	372
Venesection	373
Ammonia	373
Strychnia, belladonna, and digitalis	373
Use of anæsthetics	374
Fatty embolism	374

TRAUMATIC DELIRIUM AND DELIRIUM TREMENS.

By

WILLIAM HUNT, M.D.,

SENIOR SURGEON TO THE PENNSYLVANIA HOSPITAL, PHILADELPHIA.

Traumatic delirium	379
Meaning of term delirium	379
Connection of delirium with insanity	379
Anatomy of delirium	380
Causes of traumatic delirium	381
Hemorrhage	381
Shock	382
Embolism and thrombosis	382
Lesions of nerves of special sense	383
Bites of serpents	384
Bites and stings of insects, etc.	385
Hydrophobia, tetanus, and chorea	385
Surgical operations	385
Surgical or traumatic fever	385
Compound and simple fractures	387
Lacerated wounds	387
Burns and scalds	389
Erysipelas	391
Epilepsy and catalepsy	392
Hectic fever	392
Pyæmia, phlebitis, etc.	393
Diagnosis of traumatic delirium	393
Treatment of traumatic delirium	394
Delirium tremens	394
Causes of delirium tremens	395
Delirium tremens and mania a potu	397
Symptoms of delirium tremens	397
Diagnosis of delirium tremens	399
Treatment of delirium tremens	401

ANÆSTHETICS AND ANÆSTHESIA.

By
HENRY M. LYMAN, A.M., M.D.,
PROFESSOR OF PHYSIOLOGY AND OF DISEASES OF THE NERVOUS SYSTEM IN THE RUSH MEDICAL COLLEGE, CHICAGO.

	PAGE
Meaning of term anæsthesia	403
History of anæsthesia	403
Early history	403
Nitrous oxide gas	404
Ether	404
Chloroform	405
Phenomena of anæsthesia	406
Effect of inhalation on air-passages	406
Effect on eyes	406
Effect on general sensibility	406
Effect on brain	407
Effect on power of volition	407
Effect on power of muscular movements	407
Effect on reflex action	408
Effect on respiration	408
Effect on action of heart	408
Effect on temperature	408
Effect on secretions	408
Physiology of anæsthesia	409
Mode of administering anæsthetics	412
Accidents of anæsthesia	412
Syncope	412
Asphyxia	412
Toxic effect on nervous centres	414
Influence of rate of inhalation	414
Influence of age, sex, temperament, etc.	414
Influence of cerebral and spinal diseases	414
Influence of intra-thoracic diseases	415
Influence of excitement or terror	415
Treatment of accidents of anæsthesia	415
Employment of anæsthetics	416
Anæsthesia in surgery	416
Anæsthesia in obstetrics	416
Anæsthesia in dentistry	417
Local anæsthesia	418
Other modes of producing anæsthesia	419
Electricity	419
Rapid respiration	419
Intravenous injections	419

PAGE

Anæsthetic mixtures 420
Hypnotism 421
Compression 422
Mortality consequent upon artificial anæsthesia 422
Mortality from chloroform 422
Mortality from ether 423
Mortality from nitrous oxide 423
Post-mortem appearances after death from artificial anæsthesia . . 423
Anæsthetic substances 424
Hydrocarbons and their derivatives 424
Methane 424
Ethane 424
Tetrane 424
Pentane 425
Octane 425
Ethylene 425
Amylene 425
Turpentine 425
Benzene 425
Methylic chloride 426
Methylene bichloride 426
Chloroform 426
Carbonic tetrachloride 426
Methylic iodide 427
Iodoform 427
Hydrochloric ether 427
Dichlorethane 427
Trichlorethane 428
Aran's ether 428
Bromide of ethyl 428
Hydriodic ether 429
Monochlorotetrane 429
Chloride of amyl 429
Iodide of amyl 429
Nitrite of amyl 429
Pyrrol 429
Alcohols 430
Wood spirit 430
Alcohol 430
Carbolic acid 430
Chloral hydrate 430
Butylchloral hydrate 430
Ethers 431
Methylic ether 431
Ether 431
Methylal 431
Ethereal salts 431
Nitric ether 431

PAGE
Formic ether 432
Acetic ether 432
Aldehydes 432
Ketones 432
Inorganic substances 432
Nitrogen 432
Nitrous oxide 432
Carbonic oxide 433
Carbonic acid 433
Bisulphide of carbon 433
Supplementary note as to deaths from chloroform 433

OPERATIVE SURGERY IN GENERAL.

By

JOHN H. BRINTON, M.D.,

LECTURER ON OPERATIVE SURGERY IN THE JEFFERSON MEDICAL COLLEGE, AND SURGEON TO THE JEFFERSON MEDICAL COLLEGE HOSPITAL, SURGEON TO THE PHILADELPHIA HOSPITAL, AND TO ST. JOSEPH'S HOSPITAL, PHILADELPHIA.

Qualifications of a surgeon 435
Personal qualifications 435
Knowledge of anatomy 436
Demeanor 437
Selection of cases, etc. 437
Diagnostic power 438
Preparation for an operation 438
Operations of necessity and expediency 439
Time for operation 439
Preparation of patient 440
Rest 440
Preliminary treatment 441
Anæsthesia 441
Comparison of ether with chloroform 442
First insensibility from ether 443
Administration of ether 443
After-treatment of ether anæsthesia 445
Administration of chloroform 446
Local anæsthesia 447
Other means of producing anæsthesia 448
Mode of conducting an operation 448
Assistants 449
Posture of patient 449
Immediate dangers 449
Instruments 450
Use of blunt knives 451

	PAGE
Drainage	451
After-dressing	451
Treatment of patients after operation	452
Diet	453
Care of bladder and bowels	454
Hygienic surroundings	454
Traumatic or surgical fever	455
Conditions determining results of operations	456
General condition of patient	457
Obesity	457
Plethora	458
Leanness	458
Habits of patient	458
Drunkenness	458
Gluttony	459
Influence of nervous system	459
Age and sex	459
Age	459
Sex	460
Race and temperament	461
Seasons and weather	461
Locality	463
Visceral affections	463
Heart and arteries	463
Lungs	464
Urinary organs	465
Liver	467
Bowel affections	467
Cachexiæ	468
Conditions connected with operation itself	469
Hemorrhage	469
Shock	469
Local condition	470
Hemorrhagic diathesis	470
Condition of patient after operation	470
Hospital hygiene	471
Causes of death after operations	472
Hemorrhage	472
Shock	473
Delirium	475
Thrombosis and embolism	475
Air in veins	476
Gangrene and sloughing	476
Tetanus	476
Erysipelas	477
Pyæmia and septicæmia	477

MINOR SURGERY.

By

CHARLES T. HUNTER, M.D.,

DEMONSTRATOR OF ANATOMY IN THE UNIVERSITY OF PENNSYLVANIA; SURGEON TO THE EPISCOPAL HOSPITAL, PHILADELPHIA.

	PAGE
Surgical dressings	479
Lint	479
Charpie	479
Tow	479
Oakum	480
Cotton	480
Paper-lint	480
Jute	480
Compresses	480
Pledget	481
Tent	481
Mèche	481
Pellets and bullets	481
Retractors	481
Oiled silk	482
Gutta percha or rubber tissue	482
Waxed paper	482
Water-proof paper	482
The protective	482
Mackintosh	483
Use of bandages	483
Roller bandages	483
General rules for bandaging	484
Special bandages	485
Circular bandage	485
Oblique bandage	485
Spiral bandage	485
Spiral reversed bandage	485
Spiral bandages	486
Spiral reversed of upper extremity	486
Spiral of finger	486
Spiral of hand or demi-gauntlet	486
Spiral reversed of lower extremity	487
Spiral of chest	488
Spiral of penis	488
Spica bandages	488
Spica of thumb	489
Spica of shoulder	489
Spica of groin	489

	PAGE
Spica of both groins	490
Spica of foot	490
Figure-of-eight bandages	491
Figure-of-eight of elbow	491
Anterior figure-of-eight of chest	491
Posterior figure-of-eight of chest	492
Suspensory and compressor of breast	492
Suspensory and compressor of both breasts	493
Velpeau's bandage	493
Bandages for the head	493
Figure-of-eight bandage of head and jaw	493
Crossed or oblique bandage of angle of jaw	494
Recurrent bandage of head	494
V-bandage of head	495
Other roller bandages	495
Recurrent bandages for stumps	495
Single T-bandage	496
Double T-bandage	496
Sling or four-tailed bandage	496
Many-tailed bandage of Scultetus	497
Handkerchief bandages	497
Fixed dressings or hardening bandages	498
Plaster-of-Paris bandage	498
Starch bandage	500
Gum and chalk bandage	500
Silicate of potassium bandage	500
Paraffin bandage	500
Glue and oxide of zinc bandage	500
Revulsion and counter-irritation	500
Rubefacients	501
Vesicants	501
Acupuncture	502
Issues	502
Moxa	503
Seton	503
Actual cautery	504
Paquelin's cautery	505
Bloodletting	505
Scarification	505
Puncturation	505
Cupping	505
Dry-cupping	505
Wet or bloody-cupping	506
Leeching	507
Artificial or mechanical leech	508
Venesection	508
Bleeding from external jugular	509
Bleeding from internal saphena	509

	PAGE
Arteriotomy	509
Transfusion of blood	509
Direct transfusion	510
Aveling's method	510
Roussel's method	511
Indirect transfusion	511
Hewitt's method	511
Allen's method	512
Other methods	513
Arterial transfusion	513
Auto-transfusion	513
Intra-venous injection of milk, etc.	513
Artificial respiration	514
Mouth to mouth inflation	514
Richardson's bellows	515
Howard's direct method	515
Sylvester's method	515
Marshall Hall's ready method	516
Vaccination	516
Revaccination	517
Hypodermic injections	518
Aspiration	519
Surgical uses of electricity	521
Electrolysis	522
Galvano-cautery	523
Galvanization and faradization	525
Massage	525
Stroking or effleurage	525
Kneading or pétrissage	525
Percussion or tapotement	526
Passive and active motion	526
Muscle-beating	526
Use of the thermometer in surgery	527
Clinical thermometer	527
Surface thermometer	528
Use of the sphygmograph	529

PLASTIC SURGERY.

By

CHRISTOPHER JOHNSTON, M.D.,

EMERITUS PROFESSOR OF SURGERY IN THE UNIVERSITY OF MARYLAND, BALTIMORE.

Synonyms	531
History of plastic surgery	532
Lesions remediable by plastic surgery	533

PAGE
General principles of plastic operations 535
Classification of plastic operations 536
General rules for plastic operations 537
Skin grafting 538
Hamilton's observation 539
Reverdin's observations 539
Poncet's observations 543
Bryant's observations 543
Coste's observations 543
Ollier's observations 544
Pollock's observations 544
Bert's observations 546
Martin's observations 546
Hodgen's observations 547
Donnelly's observations 549

AMPUTATIONS.

By

JOHN ASHHURST, Jr., M.D.,

PROFESSOR OF CLINICAL SURGERY IN THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA.

General remarks upon amputation 551
History of amputation 552
Among the Greeks and Romans 552
Among the Arabians 553
During the middle ages 553
Invention of the ligature 554
Invention of the tourniquet 555
History of circular operation 556
History of flap operation 558
Conditions calling for amputation 559
Avulsion of a limb 559
Compound fractures and luxations 560
Lacerated and contused wounds 560
Gunshot injuries 561
Lesions of arteries 562
Effects of heat and cold 562
Mortification 562
Dry gangrene 563
Hospital gangrene 563
Diseases of bones and joints 564
Morbid growths 564
Tetanus 564
Deformities 564

PAGE
Instruments required for amputation 565
Tourniquet 565
Esmarch's apparatus 569
Amputating knives 570
Saws 571
Cutting pliers or bone-nippers 573
Bone forceps 573
Artery forceps and tenacula 574
Ligatures 575
Retractor 577
Sutures 577
Needles 578
Dissecting forceps 578
Scissors 579
Operative methods employed in amputation 579
Circular operation 579
Modified circular operation 582
Elliptical operation 583
Oval operation 584
Method of Scoutetten 584
Method of Malgaigne 584
Single flap operation 584
Double flap operation 585
Ravaton's method 585
Vermale's method 585
Sédillot's method 586
Langenbeck's method 587
Teale's method 587
Lister's method 588
Relative advantages of different modes of amputating 589
Simultaneous or synchronous amputations 590
Table of cases of synchronous amputation 592
Dressing the stump 593
Cold-water dressing 593
Air dressing 594
Pneumatic occlusion and pneumatic aspiration 595
Perchloride of iron dressing 596
Open method 597
Antiseptic dressing 597
Wadding dressing 598
Bordeaux and earth dressings 598
Simple dressing 599
After-treatment of stump 600
Structure and diseases of stumps 601
Structure of stumps 601
Diseases of stumps 601
Sloughing 602
Erysipelas and diffuse cellulitis 602

PAGE
Hospital gangrene 602
Spasm of muscles 602
Retraction of muscles 602
Contraction of tendons 603
Hemorrhage 603
Aneurism, etc. 604
Neuromata 604
Periostitis, osteitis, and osteomyelitis 604
Necrosis 605
Caries 605
Hypertrophy of bone 606
Adventitious bursæ 606
Prothetic apparatus and adaptation of artificial limbs 606
Prothetic apparatus for upper extremity 607
Prothetic apparatus for lower extremity 608
Mortality and causes of death after amputations 610
Table of one hundred cases of amputation 612
Analysis of causes of death in above cases 617
Effect of age 618
Effect of constitutional condition 622
Effect of sex 622
Effect of hygienic surroundings 623
Erysipelas, pyæmia, etc. 624
Effect of nature of lesion 625
Effect of period of amputation 627
Effect of part involved 629
Special amputations of the upper extremity 631
Amputations of fingers 631
Through phalanx 631
Through interphalangeal joint 631
Entire finger 632
Two adjoining fingers 634
All four fingers 634
Amputations of hand 634
Thumb through metacarpal 634
Thumb with metacarpal 634
Through one or more metacarpals 635
Fifth metacarpal 636
Other metacarpals 636
Whole metacarpus 636
Amputation at the wrist 637
Circular method 637
Elliptical method 638
Flap methods 638
Amputation of the forearm 639
Circular method 639
Flap methods 639
Mixed methods 640

PAGE
Amputation at the elbow 640
Elliptical method 640
Circular method 640
Flap methods 641
Amputation of the arm 642
Circular method 642
Oval method 643
Flap methods 643
Amputation at the shoulder 643
Oval method (Larrey) 644
External flap method (Dupuytren) . . . 645
Antero-posterior flap method (Lisfranc) 646
Amputation above the shoulder 647
Special amputations of the lower extremity 649
Amputations of toes 649
Through phalanges 649
At interphalangeal joint 649
At metatarso-phalangeal joint 649
All toes simultaneously 650
Amputations of the foot 650
Fifth toe with metatarsal 650
Great toe with metatarsal 650
Two or more metatarsals 651
Through continuity of metatarsus 651
Entire metatarsus 652
Hey's amputation 652
Lisfranc's amputation 652
At medio-tarsal joint (Chopart) 653
Sub-astragaloid amputation 654
Hancock's amputation 655
Tripier's amputation 655
Other amputations 655
Amputations at the ankle 656
Syme's amputation 656
Roux's amputation 658
Pirogoff's amputation 658
Fergusson's modification 659
Le Fort's modification 659
Amputation of the leg 660
Amputation in the lower third 660
Amputation in the middle or upper third 660
External flap method (Sédillot) 661
Lee's method 662
Amputation above point of election 662
Amputations at the knee and knee-joint 663
Amputation at the knee-joint 663
Elliptical method 663
Posterior flap method 664

PAGE
Anterior flap method 664
Lateral flap method 664
Amputation at the knee 665
Carden's amputation 665
Gritti's amputation 665
Stokes's amputation 666
Amputation of the thigh 667
Amputation in lower third 667
Amputation in middle or upper third 668
Amputation through trochanters 669
Amputation at the hip-joint 669
Oval method 670
Modified circular method 671
Single flap method 671
Antero-posterior flap method 672
Liston's method 672
Béclard's method 672
Guthrie's method 672
Lateral flap method 674
Larrey's method 674
Lisfranc's method 674
Dupuytren's method 674
Control of hemorrhage during hip-joint amputation 674
Table of cases of hip-joint amputation 678

INDEX 703

LIST OF ILLUSTRATIONS.

CHROMO-LITHOGRAPHS, ETC.

PLATE		PAGE
I.	Lung showing pyæmic (metastatic) abscesses in various stages	211
II.	Section of liver showing pyæmic or metastatic abscesses	211
III.	Primary synchronous amputation of left leg and right hip-joint	591

WOOD-CUTS, ETC.

FIG.		
1.	Diagram illustrating condition of hyperæmia	2
2.	Effect of injections of nitrate of silver on capillaries	6
3.	Contraction of capillaries	9
4.	Glandular vesicle of frog	10
5.	The same, with lumen of acinus filled up under action of stimulus	10
6.	Effect of nitrate of silver solution on cornea	29
7.	Fibrillar fasciculi and cells in tendon	37
8.	Temperature chart of erysipelas	180
9.	Skeleton of rachitic infant	253
10.	Head of rachitic child	263
11.	Rachitic spinal curvature in adult	264
12.	Rachitic deformity of head, ribs, and radius	265
13.	Deformity of chest from rachitis	266
14, 15, 16.	Rachitic deformities of pelvis	267
17, 18.	Rachitic deformities of femur	267
19, 20.	Rachitic deformities of femur, tibia, and fibula	268
21.	Appearance of child suffering from caries of vertebræ	344
22.	Mode of stooping in subject of spinal caries	344
23, 24.	Clinical thermometers	348
25, 26.	Æsthesiometers	350
27.	Dynamometer	352
28.	Temperature chart of fatal traumatic delirium following excision of elbow	386
29.	Temperature chart of traumatic delirium following amputation of hand	388
30.	Temperature chart of fatal traumatic delirium following burns	389
31.	Temperature chart of fatal traumatic delirium following scalds	390
32.	Temperature chart of traumatic delirium following burns	391
33.	Temperature chart of fatal mania-a-potu	397
34.	Temperature chart of delirium tremens following fracture of femur	399

FIG. PAGE
35. Temperature chart of delirium tremens following compound fracture of leg, etc. 400
36. Temperature chart of delirium tremens following fracture of patella . 401
37. Codman and Shurtleff's inhaler for nitrous oxide 413
38. The same, adapted for inhalation of ether 413
39. Clover's inhaler for ether and nitrous oxide 413
40. Porte-mèche 481
41. Bandage winder 483
42. Mode of rolling bandage by hand 484
43. Single-headed roller 484
44. Double-headed roller 484
45. Circular, oblique, and spiral turns of bandage 485
46. Mode of making reverses 485
47. Spiral reversed bandage of upper extremity 486
48. Spiral bandage of finger 487
49. Spiral bandage of hand, or demi-gauntlet 487
50. Spiral reversed bandage of lower extremity 487
51, 52. American spiral of lower extremity 488
53. Spiral bandage of penis 488
54. Spica bandage of thumb 489
55. Spica bandage of shoulder 489
56. Spica bandage of groin 490
57. Spica bandage of both groins 490
58. Spica bandage of foot 490
59. Anterior figure-of-eight bandage of chest 491
60. Posterior figure-of-eight bandage of chest 492
61. Suspensory and compressor bandage of breast 492
62. Suspensory and compressor bandage of both breasts . . . 492
63. Velpeau's bandage 493
64. Barton's bandage for jaw 494
65. Crossed or oblique bandage of angle of jaw 494
66. Recurrent bandage of head 495
67. V-bandage of head 495
68. Recurrent bandage of stumps 495
69. Bandage of Scultetus 497
70. Apparatus for winding plaster bandages 498
71. Seutin's pliers for removing fixed bandages 499
72. Von Bruns's pliers 499
73. Saw for removing plaster-of-Paris bandages 499
74. Porte-moxa 503
75. Seton-needle 503
76. Cauting irons of various shapes 504
77. Paquelin's thermo-cautery 504
78. Cupping glass and portable air pump 506
79. Scarificator for wet-cupping 506
80. Cupping glass with India-rubber bulb 506
81. Mechanical leech 507
82. Aveling's transfusion apparatus 510

FIG.		PAGE
83.	Roussel's apparatus for transfusion	511
84.	Allen's transfusion apparatus, modified	512
85.	Funnel and tube for intra-venous injection of milk	513
86.	Strainer for intra-venous injection of milk	514
87.	Richardson's bellows for artificial respiration	515
88.	Syringe for hypodermic injections	518
89.	Mode of giving hypodermic injection	519
90.	Dieulafoy's aspirator	520
91.	Potain's aspirator	521
92.	Constant galvanic battery	522
93.	Byrne's cautery battery	523
94.	Electrodes for galvanic cautery	524
95.	Faradic battery	525
96.	Clinical thermometer	527
97.	Surface thermometer	528
98.	Pond's sphygmograph	530
99.	Amputation of foot with cutting forceps	554
100.	Amputation with chisel and mallet	555
101.	Morel's tourniquet	556
102.	Morel's tourniquet improved	556
103.	Application of common tourniquet	557
104.	Petit's tourniquet	557
105.	Modern tourniquet	566
106.	Field tourniquet	566
107.	Signoroni's horse-shoe tourniquet	566
108.	Skey's tourniquet	567
109.	Hoey's clamp	567
110.	Gross's arterial compressor	567
111.	Pancoast's abdominal tourniquet	568
112.	Lister's aortic compressor	568
113, 114.	Esmarch's elastic bandage and tube	569
115.	Old knife for circular amputation	570
116, 117.	Modern amputating knives	571
118.	Double-edged catlin	571
119, 120.	Bistoury and scalpel	571
121.	Knife for finger amputations	571
122.	Metacarpal knife	571
123.	Amputating saw	572
124.	Bow-saw	572
125.	Small saw with movable back	572
126.	Rust's saw	572
127.	Butcher's saw	573
128.	Liston's cutting bone forceps	573
129.	Fergusson's lion-jawed forceps	573
130.	Farabeuf's forceps	574
131.	Cross-spring forceps	574
132.	Catch forceps	574
133.	Slide forceps	574

FIG. PAGE
134. Tenaculum 575
135. Serre-fines 575
136, 137. Nunneley's clips 575
138. Reef or sailor's knot 576
139. Surgeon's knot 576
140. Granny knot 576
141. Various form of needle 578
142. Needle eyed near point 578
143. Dissecting forceps 578
144. Bandage scissors 579
145. Scissors curved on flat 579
146. Amputation of arm by circular method 581
147. Amputation of thigh by modified circular method . . . 583
148. Amputation at elbow by elliptical method 583
149. Amputation of fingers by oval method 584
150. Amputation of forearm by double flap method 586
151. Amputation of forearm by Teale's method 587
152. Stump resulting from amputation by Teale's method . . 588
153. Irrigating apparatus for cold water dressing 594
154, 155. Artificial arm 607
156, 157, 158. Artificial hands 608
159. Box leg 608
160, 161, 162. Artificial legs 609
163. Artificial foot 610
164, 165. Artificial legs 610
166. Skeleton of finger, showing relation of knuckles and joints . . 631
167. Amputation of finger by palmar flap method 632
168. Amputation of entire finger by double flap method . . . 633
169. Amputation of two fingers by oval method 634
170. Result of partial amputation of hand 634
171. Amputation of right thumb by palmar flap method . . . 635
172. Amputation of left thumb by palmar flap method 635
173. Amputation of fifth metacarpal by internal flap method . . . 636
174. Amputation at wrist by palmar flap method 638
175. Amputation at elbow by external flap method 641
176. Amputation of arm by oval, or Guthrie's method . . . 642
177. Amputation at shoulder by oval, or Larrey's method . . . 644
178. Result of shoulder-joint amputation by Larrey's method . . . 645
179. Amputation at shoulder by external flap, or Dupuytren's method . . 645
180. Result of shoulder-joint amputation by Dupuytren's method . . 646
181. Chain saw 648
182. Amputation of toe by oval method 649
183. Amputation of fifth toe and metatarsal by oval method . . . 650
184. Amputation of great toe and metatarsal by internal flap method . . 651
185. Amputation of entire metatarsus by Lisfranc's method . . . 652
186. Amputation at medio-tarsal joint by Chopart's method . . . 653
187. Sub-astragaloid amputation 654
188. Stump from sub-astragaloid amputation 655

FIG. PAGE
189. Amputation at ankle by Syme's method 657
190. Amputation by Pirogoff's method 658
191. Amputation of leg by external flap, or Sédillot's method . . . 661
192. Amputation of leg by Lee's method 662
193. Amputation at knee-joint by anterior flap method 664
194. Amputation at knee by Carden's method 665
195. Amputation of thigh by double flap method 668
196. Amputation at hip-joint by Béclard's method 672
197. Amputation at hip-joint by Guthrie's method 673
198. Wound after amputation at hip-joint by Guthrie's method . . 673
199. Result of hip-joint amputation by Guthrie's method . . . 674

THE INTERNATIONAL ENCYCLOPÆDIA OF SURGERY.

DISTURBANCES OF NUTRITION; THE PATHOLOGY OF INFLAMMATION.

BY

S. STRICKER, M.D.,

PROFESSOR OF EXPERIMENTAL AND GENERAL PATHOLOGY IN THE UNIVERSITY OF VIENNA.

TRANSLATED BY

ALFRED MEYER, M.D.,

OF NEW YORK.

Hyperæmia.

The expression *Hyperæmia* signifies a repletion of the bloodvessels with blood. When, however, the entire circulatory system is overfilled, we designate this condition as *Plethora*. The term hyperæmia has reference only to a certain territory, to a certain organ or portion of an organ. Consequently, when we make use of the word "hyperæmia," we must add the region in which this overfilling with blood has its seat. We accordingly speak of a hyperæmia of the liver, of the kidney, or of the brain; but we do not say that a man is suffering from hyperæmia.

As soon as the bloodvessels dilate, their contents must increase. On the other hand, hyperæmia without dilatation of the bloodvessels is an impossibility. Hyperæmia and dilatation of bloodvessels are consequently conditions which are intimately connected. If we inject a colored fluid into an organ, we observe that it assumes the color of the injected mass only when the capillaries become filled with the same. If we employ a substance which does not find its way into the capillaries (*e. g.*, cinnabar suspended in wax), only the arteries or veins become colored, according as we have made the injection into the former or into the latter. For the arteries and veins of an organ only form single branches, whereas the capillaries traverse the entire organ, forming a network so dense that we cannot see its meshes with the

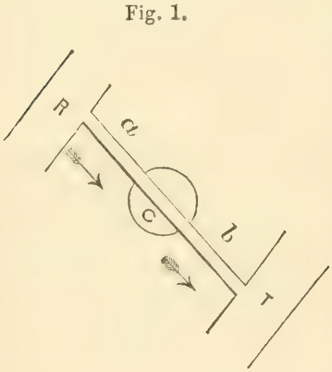
naked eye. Accordingly, when this capillary network is filled with a colored fluid, the entire organ is diffusely colored. Now, since hyperæmia is characterized by a diffuse coloration of the entire hyperæmic region, we may conclude with certainty that in hyperæmia the capillaries are dilated.

Active Hyperæmia.—In the skin, and in the mucous membranes which are accessible to inspection, active hyperæmia is characterized by a diffuse, bright-red (arterial) coloration. The reddened parts are also warmer to the touch than those around them. We know already what the diffuse coloration denotes. It is the expression of the fulness of the capillaries. The color is bright red, because the capillaries are filled with bright-red, arterial blood. But whence originates the elevation of the temperature?

When the skin becomes bloodless, it cools off; it assumes the temperature of the surrounding medium. The instant it becomes colored bright red, in consequence of a dilatation of the bloodvessels, it also becomes warmer. It is therefore probable that the skin is heated by the blood; that the bloodvessels behave here like a system of pipes in a steam-heating apparatus. When warm water circulates through these, the air in the neighborhood of the pipes becomes heated; when the fluid which has entered is removed, the surrounding air cools off. In view of this state of affairs, we are led to suppose that the more quickly the blood circulates through a portion of the skin, the warmer the latter will become. And manifestly this increase of heat can proceed until the temperature of the hyperæmic territory has reached that of the blood. On the other hand, we may conclude, from the increased warmth at the seat of *fluxion* (or active hyperæmia)—a condition the existence of which is readily demonstrated—that the blood-current is accelerated in the congested part. As we shall see hereafter, the fact of such an acceleration has been actually shown by experiment.

Our experience with regard to the acceleration of the blood-current leads us to still further conclusions. Let R and T (Fig. 1) represent two rivers. These rivers are to be connected by a canal *a b*. Let us suppose, furthermore, that the water in R has a greater descent than in T, and consequently flows through the canal in the direction of the arrows from R to T. If now the canal *a b* be widened at a place *c*—let us say by introducing a reservoir at *c*—at the moment of widening, the current will flow somewhat more rapidly from *a* to *c*, and the acceleration will continue until the reservoir *c* is filled. But as soon as this is accomplished the water will not flow more quickly than before, either at *a* or at *b*, while at the seat of the widening *c*, it will even flow more slowly than at other points. If the current in the narrow parts of the canal *a b*, on either side of the reservoir *c*, is to be accelerated, this canal must be widened in its entire extent from one mouth to the other. Let us now suppose that R is a large artery, T a large vein, *a* a small artery which goes into a hyperæmic portion of the skin, *c* its capillary plexus, and *b* the small vein which carries back the blood of the congested region into the large vein. Now it is easy to understand that a dilatation of the capillaries alone is not sufficient to produce a permanent acceleration of the blood-current, and a permanent elevation of the temperature. For the production of this result the entire vascular system of this region must be dilated —the small artery, the capillaries, and the small vein up to its entrance in the

Fig. 1.



nearest large venous trunk. Only under these circumstances can the blood flow more rapidly through the part, and cause an elevation of its temperature.

Passive Hyperæmia.—The condition of *Passive Hyperæmia* is, in the skin, characterized by a diffuse, venous coloration, and by a temperature which is relatively low. The diffuse coloration here, too, points to a dilatation of the capillaries, but the low temperature makes us presume that the blood-current in the capillaries is retarded. In the same way, too, we can explain the venous color. When the blood flows more quickly than usual through the capillaries, it is not so deeply venous as it ordinarily is when it reaches the veins, or, in other words, it is of a brighter red. When it flows more slowly than usual, it is, on the other hand, more intensely venous. It is thus quite consonant with what has been said that an actively hyperæmic skin should be colored bright red, and that a passively hyperæmic skin should be, on the contrary, of a venous color; and it is therefore proper to designate an active hyperæmia as a *fluxion*, and a passive hyperæmia as a *stagnation*. If a *hyperæmia of stagnation* is to be produced, the blood must meet with a hindrance in its course. Furthermore, if the direction of the blood-current is a normal one, this hindrance must be located on the side of the vein. For an obstruction in the arteries would prevent the filling of the capillaries, and an obstruction in the capillaries themselves would likewise diminish their contents; in either case *Ischæmia* and not *Hyperæmia* would be the result. The obstruction can produce an overfilling only when it is located on the venous side of the circulation; for under such circumstances only can the capillaries become filled and overfilled with blood streaming in from the arteries. There is, however, one exception to this general rule, viz., in the case of the reflux from the veins. To avoid repetition, this exception will be considered on a subsequent page (p. 20).

Anæmia and Ischæmia.

The word *Anæmia* is ordinarily employed in contradistinction to *Plethora*. Anæmia accordingly means an abnormal diminution in the amount of the blood. But this definition is not to be accepted literally. We call a person *anæmic* when his face, his lips, his gums appear pale; but the paleness is not necessarily due to a diminution in the total amount of blood. The individual may have the normal amount, or even an abnormally large amount, of blood, and still look pale, because of the number of red blood-corpuscles being decreased, and of their being replaced by something else. In *leucocythæmia*, for example, we have a marked decrease of red blood-corpuscles and an increase of white ones. The blood of a person suffering from leucocythæmia is not in fact of so deep a red as normal blood, but not so much because it has too many white corpuscles as because it contains too few red ones. The blood would be just as pale even if the white globules were replaced by any other colorless mass, such, for example, as blood plasma. The pale look of a person who has the normal number of red blood-corpuscles may, moreover, be due to a deficiency in the amount of their red coloring matter, each red blood-corpuscle, under such circumstances, appearing less intensely colored than is normally the case.[1]

In regard to the condition itself, however, it is of subordinate importance to know which of the aforesaid causes lies at the bottom of the paleness, since under any circumstances it depends mainly on the deficiency of red coloring

[1] Duncan, Wiener Sitzungsberichte, 1867.

matter. It is this coloring matter (*hæmoglobine*) which takes up the oxygen in the lungs, and then, while its carriers, the red blood-corpuscles, pass through the capillaries, provides for the interchange of oxygen and carbonic acid—for the internal respiration. Now it is in the main immaterial whether the coloring matter is diminished because there is a want of blood, or because the number of red blood-corpuscles is too small, or because they are too pale. On the other hand, a diminution of the total amount of blood cannot be diagnosticated at the bedside at all, with the means now at our command. Even in the case of anæmia after loss of blood, we cannot assert with certainty that it is really the diminution of the total amount of blood which produces the features of the disease. The researches of C. Ludwig and his pupils have shown us that the blood is very rapidly replaced after hemorrhages, probably by the entrance of colorless lymph into the vascular system; while I have shown,[1] on the other hand, that a frog, for whose blood a dilute solution of salt has been as thoroughly as possible substituted, has, a few hours afterwards, a very large number of white blood-corpuscles circulating in the vessels, with a small number of red globules. Finally, we must take into consideration the fact that the pale color of the face, lips, and gums, and, in general, of every organ, may also be produced by a permanent contraction of the blood-vessels. In this instance, too, the word *anæmia* is used, but here in contradistinction to *hyperæmia*. In the case of local poverty of blood the expression *ischæmia* is indeed used; but we very commonly speak of anæmia of the liver, of the kidney, or of the brain, entirely without regard to the total amount of blood.

Causes of Hyperæmia and Ischæmia.

The immediate cause of hyperæmia as well as of ischæmia is doubtless to be found, as I have already (page 1) remarked, in a change of calibre of the bloodvessels. The question therefore turns upon a second cause, namely, that of the contraction and dilatation of the vessels. I shall divide the answer to this question into several parts. I shall first speak of the well-known arrangements in the vessels for the production of contraction; I shall next devote a separate section to the contractility of the capillaries; I shall then treat of the *modus operandi* of these movements separately; and, finally, the nerves which govern the contractions will be considered.

The Contractile Elements of the Bloodvessels.—The arteries have a sheath of circularly-arranged, smooth, muscular fibres, by the contraction of which the lumen must be narrowed. The larger the artery, the more does this coat of smooth muscular fibres become mixed with elastic elements, and the more is the contractility of the entire tube impaired. The capability of contraction is accordingly much more marked in the smaller arteries than in the large ones, the smallest arteries having indeed the power of contracting until their lumen has disappeared. When the contraction of the circular muscles subsides, the arteries must widen again and refill, in consequence of the pressure which the blood (really the heart) exerts upon them. Thus contraction of the circular muscular fibres causes a narrowing of the vessels, while relaxation of the circular muscular fibres produces a widening of the same. It is generally supposed that the elastic tissue also takes part in the narrowing of arteries, for it is thought that the elastic fibres are distended by the impulse which the blood receives during systole, and assume their former dimensions during diastole. It is, indeed, true that the arterial wall is

[1] Studien aus dem Instit. f. experim. Path., 1869.

distended in consequence of every systole; but it is not proved that the so-called elastic substances of the arterial wall are involved in this distension. In general, we do not know whether the elastic substances of the organism possess any elasticity worth mentioning. We must not be deceived by the name "elastic;" the fibres have been called elastic, because the filaments of a torn end curve inward like elastic springs; but we do not know if these fibres are distensible like caoutchouc; I do not even consider it at all likely. The researches of Spina[1] show that the elastic fibres are cells which have become old and resistant; cells (or processes of cells) which, in inflammation, again become as soft, as mobile, and as capable of proliferation, as young cells of the embryo. There is no reason for considering the cells which have become resistant to be more distensible than the other tissues. I regard it as more likely that the artery, as a whole, possesses a certain degree of elasticity, and that it *in toto* possesses the power to contract after a certain distension, as soon as the pressure or tension relaxes.

The walls of veins likewise have smooth muscular fibres, but not circularly arranged, as in arteries. And yet the veins are contractile in a marked degree. If we irritate mechanically the exposed jugular vein of a rabbit, it contracts until its lumen almost disappears. The contraction of veins is the more striking because they are also very distensible. As soon as the blood-current is obstructed in the jugular vein, the vessel swells, although the blood flows in it under a very low pressure. We know very little about the mechanism of this contraction; it is not clear how muscular fibres which run lengthwise can produce a narrowing of the lumen. The bloodvessels, however, have other arrangements besides the muscular fibres, by means of which their lumen can be contracted. These arrangements are presented by the *Intima.*

The *intima* of the bloodvessels lines the entire vascular system. In the heart, it is represented by the endocardium. The endocardium leads directly to the intima of the arteries, which is continued in the capillaries, and beyond the capillaries again becomes the intima of the veins. In the capillaries the intima lies in immediate contact with the surrounding tissue, or is only accompanied by the rudiment of an *adventitia.* In other words, the wall of the capillaries consists of nothing, or almost nothing, but the intima. Now the capillaries possess a certain degree of contractility; they can actively contract and dilate, although they have no muscular fibres. In this state of affairs we might even suspect that the veins were capable of contraction and dilatation, in consequence of the contractility of their intima. But the contractility of the capillaries has not the same character as muscular contractility. The doctrine of the contractility of the capillaries is not at all generally accepted, and only a portion of those who accept it have actually observed the phenomenon. Therefore we must not blindly admit this doctrine, and build up theories upon it. We must first familiarize ourselves more closely with it, and, as it is a subject of very great importance in pathology, and especially in respect to the theory of inflammation, I shall devote a separate section to its consideration.

THE CONTRACTILITY OF THE CAPILLARIES.—In the year 1865, I for the first time advanced the assertion that the walls of the capillaries were not, as was at that time supposed, mere lifeless, structureless,[2] elastic membranes, but that they consisted of a contractile substance. I had observed that the capillaries of the freshly-prepared *membrana nictitans* of the frog, when

[1] Mediz. Jahrbücher, 1873 und 1875.

[2] Nuclei had indeed been ascribed to them, but with this single exception they were considered structureless.

examined in the aqueous humor, changed their lumens; that in certain places they alternately narrowed and widened. These observations, however, were merely accidental In some of these membranes I saw the change; in many others I did not succeed in observing it. But, as it was already known at that time that the cells of embryos were distinguished by their contractility, I chose the tadpole for a further examination of the subject. For the tadpole is the embryo of the frog, and has this advantage, that the bloodvessels can be examined in its transparent tail *in vivo*—that is, as long as the circulation continues; and I found, indeed, that the capillaries of the tail[1] contracted under the influence of powerful irritation, as, for example, under the influence of strong induction currents. But I was not sure of the matter; at times I obtained a favorable result, at others not. I could, therefore, give no positive answer regarding this property of the capillaries. A number of additional circumstances, however, gave me an insight into certain other properties. I discovered on this occasion that the walls of the vessel were pierced by red blood-corpuscles[2]—a discovery on which Cohnheim subsequently based a new theory of suppuration (migration theory). I found, furthermore, that the walls of capillaries were not structureless; that here and there they were granulated, like protoplasm; that their outlines were irregular; that here and there they had points and nodules. Then I noticed that the walls of the capillaries had processes;[3] that various phases of growth of these processes were recognizable up to a junction with the processes of neighboring capillaries. It appeared that these processes became hollowed out, commencing at the root (at the inner wall of the older capillary), and were thus transformed into new capillaries.

Walls of vessels, I argued, which resemble protoplasm, which send out processes, are living walls. The capillaries are protoplasm in the shape of tubes. Just as protoplasm is permeable for foreign bodies, so, too, are the walls of capillaries. My statement concerning the penetration of the vascular wall was soon generally accepted, but its contractility, and even its permeability (my view of it), were contested. The blood-corpuscles, it was said (in opposition to my assertions), passed through openings (*stomata*) of the vascular walls.

At the same time, Eberth, Aeby, and Auerbach, discovered (but each one independently of the other) that by the injection of a solution of nitrate of silver[4] into the vascular system, a series of brown lines (Fig. 2) could be produced in the capillaries, and in the intima of arteries and veins; lines similar to those obtained on the surface of serous membrane by staining with silver. The lines on the serous membranes are regarded as the outlines of cells, and it was accordingly said that the brown lines of the capillaries were also outlines of cells; and the more so, because nuclei were recognizable in the fields that were bounded by the lines. (See Fig. 2.) Well, then, the capillaries were composed of flat cells—cells of the same kind as those which cover the serous membranes. They were the continuation of the intima (endothelium) of the arteries; the capillaries themselves were endothelial tubes. At the borders of the cells

Fig. 2.

[1] All bloodvessels, whether large or small, whether afferent or efferent, are here capillaries as regards structure. They all consist merely of an intima. There is not yet a muscular coat or an adventitia present.

[2] Studien über Bau und Leben der capill. Blutgefässe. Wiener Sitzungsberichte, 1866.

[3] The mere fact that the capillaries had processes was known previously.

[4] The method itself had already been made known by Recklinghausen.

there were stomata through which the blood-corpuscles passed. Remak, and subsequently His, had already asserted that the bloodvessels were formed by a juxtaposition of cells, and now it was said this assertion was proved. The brown lines, it was said, showed us the places of junction of the cells which formed the vessel.

It seems to me, however, that the supposition of the existence of stomata in the wall of the vessel is now generally abandoned. There is no longer any doubt that the blood-globule can pass through any point of a capillary. The supposition, too, that the bloodvessels are built up by the synthesis of cells (like a chimney) is, as far as I know, no longer supported by anybody. However, I must attribute great value to the discovery of the silver-lines. For this discovery has led me to a theory which I must now regard as fully proved; to a theory which is alike of importance for the doctrine of inflammation and for that of histogenesis. Since I was compelled to accept the existence of these brown lines, and yet, on the other hand, was convinced of the formation of capillaries by the hollowing out of a formerly solid material, I indulged in the following reflection: The capillaries really are formed by the hollowing out of masses of protoplasm. Subsequently, the outlines of single territories in the walls are differentiated (metamorphosed), and these territories appear to us like cells, on account of their nuclei. Originally, this interpretation was based on speculation only, but now, after I have worked in this direction for nearly fifteen years, after I have examined tissues of all types with regard to their normal and pathological genesis, this interpretation has become a fundamental theory.

This theory is as follows: When the egg undergoes segmentation, it is not divided into parts which fall asunder.[1] This falling apart of the subdivisions occurs at certain places only. The blood-corpuscles and the lymph-corpuscles separate completely after their division. On the other hand, cells which form a tissue remain connected at least in groups. The partition here is only apparent. A cell grows and then transforms a portion of its body (Zell-leib)[2] into a dividing line between two halves. If this process is repeated, a large number of cells, connected by such boundary lines, must finally be produced. If the cells grow without the development of boundary lines, we have very large cells produced, the so-called "giant-cells." These boundary lines are living matter, just as the cells themselves, though still differing from them in some respects; they have been formed by a chemical alteration of a portion of the body of the cell. The staining with silver assists us in recognizing their chemical differentiation; they are more deeply stained than the cells. In other words, they absorb more silver, and therefore assume a deeper brown color under the influence of light. Such boundary lines occur between endothelium and epithelium; they occur between the cells of the cornea, of cartilage, of bone, of tendons, and of other tissues. Between the endothelium and epithelium, however, they remain relatively small borders for life, whether the cells grow or not. In the cornea, in cartilage, in bone, in tendon and in other tissues, the intermediate substances (Zwischensubstanzen) increase in extent with advancing age, and this increase takes place at the expense of the cells. The cells diminish in circumference, or entire cells perish; that is to say, they are entirely converted into basis substance. I repeat it once more, they are transformed, but they remain alive; they can be metamorphosed again into the form of cells, and this is, in fact, what occurs when the tissues

[1] There are some exceptions to this rule. The first vitelline spheres of the rabbit's egg, for example, look as though they would fall apart if the vitelline membrane were not there. But that does not hold for the subsequent segmentation which concerns us most here.

[2] A. Brücke has introduced the term "Zell-leib" into literature, and it has been generally accepted. [Note of the Translator.]

suppurate. This basis-substance assumes a fixed character which varies according to the nature of the tissue; it becomes different in bone, different in tendon, and different in cartilage. And these peculiarities of the basis-substance invest the tissue with its peculiar type.

The metamorphoses of tissue sketched here will be spoken of again further on. For the present this reference will suffice to make clear the structure of the capillaries. We know now that the presence of the brown lines after staining with silver by no means allows us to conclude that the nucleated fields were once isolated and have here been connected. And we have no cause for ignoring the experience that in the tail of the tadpole the vessels develop from solid sprouts. A very excellent confirmation of this doctrine of the development of vessels is found in the researches of E. Klein[1] on the embryo chick. The first bloodvessels in the embryo can evidently not be produced as sprouts of already existing vessels. The first bloodvessels, as shown by Klein, are formed by single cells. The cells grow; the peripheral part of the enlarged body of the cell becomes bloodvessel; the central part becomes isolated from the peripheral by the formation of slits between them, so that the central part then lies in a cavity. By the subdivision of this central portion blood-corpuscles are formed.[2] We, accordingly, have to deal with an encapsulated closed bloodvessel, with blood-corpuscles in the interior. The individual capsules send out solid processes; the processes become hollowed out, they coalesce with the processes of other capsules, and thus there is formed a system of communicating canals. In principle, then, this development of a vessel is analogous to the one already delineated. In the one case, as in the other, there are masses which are at first solid, and subsequently become hollowed out. A similar mode of formation of bloodvessels also occurs in neoplasms, and Rokitansky was the first who described them as cystic formations—as cysts containing blood-corpuscles.

After all that I have already said, there can no longer be any doubt that in their embryonic state the capillaries consist of contractile protoplasm. But why do they not react invariably in the tail of the tadpole?[3] A living muscle invariably contracts under the influence of sufficiently powerful irritation, why not the capillaries? As the result of a comparison of the capillaries of a mammalian embryo with those of the tail of a tadpole, I have been led to suspect that the capillaries of the latter animal acquire, at an earlier period than those of the former, that rigidity which is peculiar, even in a more marked degree, to the vessels of the adult animal. The tadpole, though it is an embryo as regards its stage of development, still lives independently in the water, and uses its tail as a means of propulsion, even before the blood circulates in it. And it is therefore readily understood why the tissue here acquires, at an early period, the rigidity which corresponds to its developed function. Accordingly, in my experiments, I made use of the youngest tadpoles possible (1.5 centimetre long), and directed my attention principally to the vessels lying nearest the edge, because I believed that their growth began at the margin of the tail. And, true enough, I learned[4] that under these circumstances the capillaries regularly narrowed their lumens after every somewhat powerful irritation, and again dilated the same after the removal of the stimulus.

But, when I lay stress upon the fact that the capillaries react *promptly* only in an early embryonic state, I do not mean to say that the capillaries of older animals do not contract at all. If we consider certain phenomena in living

[1] Wiener Sitzungsberichte, Bd. 63.

[2] This description is schematic. The occurrences in the interior of such a cell are exceedingly variable. What I have described, however, is in principle based on observation.

[3] See page 6.

[4] Wiener mediz. Jahrbücher, 1877.

animals and in living man—for instance, how quickly the face of a man can become as pale as death—we are very easily led to suppose that the capillaries of the adult can contract until their lumen has almost disappeared; for it is difficult to imagine that an organ can look perfectly bloodless unless the capillaries have been completely emptied. If my experiments with older animals were not always successful, this may have been due to the arrangement of the experiments themselves. Originally I made all my observations on curarized tadpoles,[1] because experiments where stimuli are employed cannot be made under the microscope with living animals unless they are paralyzed; the stimulus applied to the vessel also makes the entire animal twitch, and the vessel under observation is removed from the field of view. Curare paralyzes the nerves of the voluntary muscles, and the animal lies perfectly motionless if the stimuli are not excessively powerful. But we now know that curare also weakens the vaso-motor nerves. The vessels of curarized animals do not react to stimuli as do those of the unpoisoned animal. As important, then, as these experiments may have been for the discovery of contractility in general, they are not altogether reliable for a complete and lucid representation of the subject. We must therefore remain satisfied, for the present, to accept the following as the doctrine of contractility of the capillaries: The capillaries, it has been demonstrated, possess in an embryonic state the property of responding to certain stimuli by a contraction of their lumen. With increasing age, however, they become more resistant; their irritability diminishes. We do not know if the irritability ever disappears entirely in the course of life.

The Contractility of the Capillaries compared to the Contractility of the Cells of Glands.—If we reflect, now, what contractions a tube must undergo in order to narrow its lumen, it appears that in form also the contractility of the capillaries cannot be compared with that of the muscles. When a muscle contracts it becomes shorter and thicker; but a capillary cannot diminish its length. How, then, is the narrowing of the tube brought about? Golubew[2] (a pupil of Rollett) has found that protuberances are formed on the inner wall of capillaries when contracting. By the formation of these protuberances, the lumen becomes narrower. Such swellings, said Golubew furthermore, are formed in certain places only. The capillaries therefore are contractile at these points only; here alone can they become narrower. I can confirm the statement concerning the formation of swellings, which, usually, are not exactly opposite each other. The condition is ordinarily such that the swellings are somewhat displaced laterally (as represented in Fig. 3), and the narrowed lumen of the vessel thus acquires a slightly undulating curve. But I must add that the tube becomes narrower, not only at the swollen places, but throughout its whole length, although the lumen is entirely closed at the swollen places sooner than elsewhere. Moreover, it has seemed to me as if the portions of the vessel which lacked these swellings also became thicker during the process of contraction. I say it has seemed so, because the confirmation of a minute increase in thickness is difficult. Besides it is self-evident that a tube which becomes narrower must either form folds or

Fig. 3.

[1] I cannot here go into details and recite all the subsequent variations of the experiment.
[2] Archiv für mikrosk. Anatomie, Bd. V.

its walls must become thicker. But no folds are to be recognized in the narrowed tube. For this reason, therefore, it is already probable that a narrowing of the capillaries is accompanied by a thickening of their walls. Accordingly we must imagine that the narrowing of the capillaries is brought about like that of a passively distended elastic tube.

This interpretation, however, does not yet give us a clear insight into the phenomenon. We cannot in all respects compare capillaries in a condition of dilatation with a distended elastic tube. The capillary tube can remain distended even when the blood-pressure (the power which distends the tube) is very small. Furthermore, the capillary tube dilates of itself when the stimulus which has made it contract ceases to act; it also dilates altogether without the participation of the blood-pressure, as, for example, in the *membrana nictitans* of the frog. It is probable, too, that under certain circumstances the dilatation is an active one; that the capillary tube aspirates fluid during dilatation. "Attraction of the blood," the Ancients called it, and imagined that walls of vessels had the power of attracting the blood. We are not aware of the existence of such a force, but know that the bloodvessels can actively dilate. In consequence of experiments made with regard to this question by H. Weber,[1] and then by Rynek[2] on the web of the frog, and by Vulpian[3] on the blastodermic membrane of the chick, it has become probable that the blood is really aspirated by the dilatation of the vessels. Further researches, which will be discussed in the next section, have also made us acquainted with the nerves which excite such a dilatation. We are therefore not allowed to compare (as regards the forces) the contraction of a capillary with that of a passively dilated elastic tube.

But what are the forces and arrangements on which depend the active contraction and the active dilatation? More recent researches which Spina and I[4] have made on the cells of glands are suited to make us comprehend the processes in the capillaries. These observations concern the glandular vesicles. In the skin of the frog there are glandular vesicles of the simplest construction. Each gland consists of a single acinus with an excretory duct, as is indicated in Fig. 4. The acinus is lined by a layer of cells, *a a*. Now I have already described two conditions of these cells in my Manual of Histology.[5] These cells are at times so large that they nearly fill up the lumen of the acinus, and at others, again, so small that (as in Fig. 4) they merely form an epithelial lining for the relatively large lumen. But now Spina and I have discovered[6] that these glandular cells become so much enlarged under certain stimuli as to fill up the lumen of the acinus (as in Fig. 5), and that they become smaller again after the stimulus has ceased to act upon them.

Fig. 4.

Fig. 5.

Since this observation is of general importance, I shall here briefly describe how it may be made. You must cut out the *membrana nictitans* of a living frog and spread it out in the aqueous humor on the stage of a microscope arranged for conducting electric stimuli.[7] Now cut off with scissors

[1] Müller's Archiv, 1852, Bd. I.
[2] Rynek, Untersuchungen aus dem Inst. für Physiologie in Graz. Leipzig, 1870, S. 104.
[3] Vulpian, Leçons sur l'appareil vaso-moteur, t. i. Quatrième leçon.
[4] Wiener mediz. Jahrb. 1880.
[5] American edition, pages 40 and 41.
[6] Mediz. Jahrbücher, l. c.
[7] See Manual of Histology, American edition, page 15.

the thick edges, especially the muscular layer which lies upon the lower third of the membrane, where it is inserted into the cutis. Now cover the specimen with thin covering-glass, and look, with a high power, for one of the many easily-discoverable glands, but one with as large a lumen as possible. If you allow a few currents from the induction coil[1] to pass through the specimen, the cells immediately swell up and soon fill the interior. If the current be too strong, the cells do not return again to their former position; the gland dies in this condition, with large cells occluding its lumen. But if the current be not too powerful, the cells soon again diminish in size (retract); the lumen of the acinus again becomes visible. As a rule, the lumen does not again become quite as large as it was before the stimulation, in the case of the excised membrane. But no matter, the stimulus can be reapplied and the enlargement of the cells again observed. As a general thing, the cells do not react any more after the second or third stimulation. If, however, the stimulus be indirectly applied, that is, transmitted through the nerves, we can repeat the experiment very often and always observe a complete retraction of the cells. For this purpose you must place the web of a living frog under the microscope and irritate the ischiatic nerve.[2]

When cells enlarge they must absorb fluid, since an increase of volume without an increase of mass is impossible. By a reduction in size, on the other hand, fluid must be forced out again. Now we have advanced the hypothesis that by this absorption and expression of fluid, secretion is brought about. But here this is of minor importance. Here we are only concerned with the fact that cells have been observed which actively enlarge in order to narrow a lumen, and actively retract again in order to enlarge the lumen. For this discovery proves that an active contraction as well as an active dilatation of a vessel which possesses no muscular fibres, is not without analogy.

The Vaso-motor Nerves.—The contraction as well as the dilatation of bloodvessels is regulated by the spinal cord, by means of special nerves which are called *vaso-motor*. It is true that, microscopically, the special relation between nerves and vessels is not yet sufficiently clear. We know that nerves pass between and along the vessels, but we do not yet know the terminations of nerves in the vascular walls. On the other hand, the fact of the innervation of vessels has been placed on a secure basis by experiment. The doctrine of the vaso-motor nerves, founded on vivisection experiments, may be placed by the side of descriptive anatomy, as regards the certainty of its fundamental laws. This doctrine, too, forms a natural supplement to anatomy; for in the corpse we cannot see the final terminations of the nerves, and, up to the present date at least, we have not been able, with the microscope, to distinguish the nerves in regard to their function. The microscope gives us no clue as to whether a nerve is sensory or motor, whether it obeys the will, or whether it supplies the vessels or the glandular cells. To all of these questions, vivisection experiments give us positive answers. Experimental angeioneurology, then, in view of its great importance as regards the circulation, may, from this standpoint, be regarded as one of the most important doctrines in medicine. I would even advance the opinion that no physiologist, no pathologist, no therapeutist, can follow his profession in a precise manner without being familiar with this field of inquiry.[3] What I introduce here is, indeed, only

[1] The strength of the current necessary, every one will readily find out by commencing with a very weak one and then increasing the strength until it has effect.

[2] This irritation requires special precautionary measures. See, on this point, Stricker and Spina, in the article already quoted (Mediz. Jahrbücher, S. 368).

[3] I have added this remark in order to combat the view that even this little is superfluous for the practical interests of surgery.

an incomplete portion. Remembering the practical tendencies of the physician, I shall not in these pages give more than is necessary for the comprehension of the influence of the nervous system on hyperæmia and ischæmia.

The vaso-motor nerves come from the spinal cord, as was first recognized by Waller and by Budge.[1] They pass out with the roots of the spinal nerves, and then reach their peripheral terminal expansions by various routes. We can arrange these routes into two main groups:—

A. *First Main Group.*—A large majority of the vaso-motor nerves leave the spinal nerves with the *rami communicantes*, and with the latter enter the great sympathetic. They run a short distance upward or downward in the great sympathetic, and then leave it in two ways: (1) As independent branches of the great sympathetic, as they are represented, for example, by the splanchnic nerves, which, I may remark, contain the principal mass of the vaso-motor nerves for the abdominal organs. (2) After they have ascended or descended a distance in the great sympathetic, they return again by means of *rami communicantes* to the spinal nerves, and together with these reach the parts which they supply. This arrangement holds good for the skin, the muscles, and the bones. Thus, for instance, the vaso-motor nerves of the foot leave the spinal cord with a series of roots of the dorsal and lumbar nerves, descend in the great sympathetic, leave it deep in the pelvis, and reach and enter the sciatic nerve by means of a small communicating filament.

B. *Second Main Group.*—A considerable number of vaso-motor nerves do not enter the sympathetic at all, but go directly into the corresponding spinal nerves, and reach their terminal expansions with them. Thus, the hind-paw of the dog receives both the previously mentioned nerves, which enter the sympathetic, and, on the other hand, the last-mentioned nerves, which come directly from the spinal cord with the roots of the sciatic, and reach the paw with the branches of that nerve. It will be convenient for the further discussion of this subject to designate the last-mentioned class as the direct, and the first-mentioned as the indirect supply.

The circumstance that a peripheral region of the body receives its vaso-motor nerves from many spinal roots, plays a part (as I shall show immediately) in the recovery from hyperæmia. In order to illustrate my meaning for the present by a comparison, we need only consider the case of a man who draws his income from many sources; such a man need not suffer hunger though one or several sources be exhausted. To support this comparison by another (imaginary) case from practice, let us suppose that the lumbar portion of the spinal cord has been completely separated from the dorsal portion by a projectile, but that the projectile has remained in the spinal canal, and has done no further damage, the great sympathetic being accordingly uninjured. The lower extremities will now be completely paralyzed and insensitive, because all the nerves which give them sensation and voluntary motion have been divided. This condition is incurable. After the injury, moreover, the lower extremities are warm (hyperæmic), since a considerable number of nerves have been divided, which formerly gave a certain tone to the blood-vessels. But these divided vaso-motor nerves were not the only ones which maintained the vascular tone in the limbs, for I have said that the sympathetic was uninjured. Now, as before, vaso-motor nerves from this penetrate the sciatic vaso-motor nerves which have not been at all injured by the projectile. In fact, the hyperæmia of the lower extremities passes away; they

[1] 1853. Quoted from Vulpian's Leçons sur l'appareil vaso-moteur, t. i. p. 23.

again become cool; they must, accordingly, have again acquired a vascular tone in spite of the paralysis and loss of sensation. I consider this case only hypothetically in man, because I have only experimented on dogs. But I know that persons whose spinal cords have sustained complete lesions of continuity in the lower dorsal region, have cold lower extremities during the course of the disease. Whether that which has been proved with regard to the hind-paw of the dog holds good for all other regions of skin and muscle, has not yet been ascertained; but, for reasons which I cannot explain here, it is probable that elsewhere this condition is also present. With reference to man, I hope that clinical observations will clear up this question.

The vaso-motor nerves are divided according to their function into two groups: those, irritation of which contracts the vessels, and those, irritation of which dilates them. The former, called *vaso-constrictors*, normally produce a certain tone of the bloodvessels, and hence exert a continual influence on the distribution of the blood and on the fulness of the bloodvessels. In the supposed case of injury of the spinal cord and subsequent curable hyperæmia, I, of course, had in mind only the vaso-constrictors. Their antagonists, the *vaso-dilators*, do not, as far as at present known, exert a continual influence; they act under certain conditions only, when they receive a special stimulus. The vaso-constrictors are dominated over by ganglionic cells (centres) of the spinal cord, and especially of the medulla oblongata, which plays so important a part in this function, that it for a long time was supposed to contain all the centres of the vaso-motor nerves, on which it was believed, on the other hand, that the spinal cord had no influence at all; but this supposition has not been verified. I, in particular, have shown[1] that on the boundary line between the cervical and dorsal portions of the cord there are also located important centres for the vaso-constrictors.

The nerve-centres which dominate the constrictors also control the blood pressure. This fundamental law of physiology we owe to Carl Ludwig and his pupil Thiry.[2] When the nerve-centres send out powerful impulses, and the vessels consequently become very narrow, the blood cannot flow out of the aorta readily. But since the heart pumps fresh quantities of blood into the aorta, the tension of the walls (*i. e.*, the blood pressure in the aorta) must rise. When, however, the nerve-centres do not send any impulses, or only weak ones, then the bloodvessels dilate, the blood flows out of the aorta readily, and its tension must decrease. Exactly the same thing occurs here as in every system of pipes or rivers. When the channels of discharge are obstructed, the pressure on the lateral walls above the seat of the obstruction rises. A second fundamental law, the enunciation of which we likewise owe to C. Ludwig[3] and his pupils, tells us that the bloodvessels of the abdominal viscera are the principal regulators of the blood-pressure. The bloodvessels of the abdominal viscera, that is to say, have so great a capacity, and by dilatation and contraction can increase or diminish their contents to such an extent, that they act like a mighty reservoir. If this reservoir is wide open, it can contain so large a portion of the total amount of blood that the rest of the organism becomes anæmic. An animal with complete paralysis of the vaso-motor nerves of the abdominal viscera, therefore, bleeds to death, as it were, into its own abdominal bloodvessels.

The nerves which influence these vessels lie principally, as already remarked,

[1] Wiener mediz. Jahrb. 1878. Still earlier, one of my pupils (Schlesinger), and at the same period Vulpian, had shown that it could not be the medulla oblongata alone which controlled the vaso-constrictors. The full proof, however, of the existence of such centres in the spinal cord was brought forward in my paper just quoted.

[2] Wiener Sitzungsberichte, 1864, Bd. 49.

[3] Arbeiten aus. d. physiolog. Anstalt zu Leipzig, 1867 u. ff.

in the splanchnic nerves. Therefore, when the splanchnics are divided, an intense hyperæmia of the abdominal viscera is produced, accompanied by a fall of the blood-pressure and an ischæmia of the remaining organs. The splanchnics, as I have likewise already remarked, are branches of the great sympathetic, and before entering the sympathetic leave the spinal cord with the roots of the upper dorsal nerves. If we divide the spinal cord low down, at about the border of the dorsal and lumbar portions, the points of origin of the splanchnics scarcely suffer at all. An animal thus injured is paralyzed and insensitive in its hind-legs, but otherwise may feel well, as far as the condition of the wound permits. Indeed such an animal, as a rule, becomes perfectly well and lively again, and differs externally from a healthy animal only in dragging its hind-legs. It is quite different if the division be made higher up, about the region of the second or third dorsal vertebra. In consequence of such a wound, all the vaso-motor nerves of the abdominal viscera become separated from their central ganglia; from those on the border between the cervical and dorsal portions of the cord, as well as from those in the medulla oblongata (see page 13). In consequence of this there ensues such an intense hyperæmia of the abdominal viscera, and such a considerable fall in the blood-pressure, that an ischæmia of the other organs arises which may prove fatal.

It is not, however, without importance for the physician to learn that, even after such a division of the spinal cord, the abnormal distribution of the blood is not always fatal; since the vaso-motor nerves of the abdominal viscera still remain connected with some centres which are located farther down in the dorsal portion of the spinal cord, and certainly reach as far as the region of the lower dorsal vertebræ. I have ascertained this by the following series of experiments:—

If in a dog we divide the cervical portion of the cord just below the medulla oblongata, the animal soon ceases to breathe, because the nervous centres of respiration in the medulla oblongata (with which Legallois and subsequently Flourens have made us acquainted) are separated from the peripheral nerves of respiration. But if we employ artificial respiration, as is generally the practice in vivisection experiments, we can keep up the circulation and heart-beats respectively for hours. True, the blood-pressure is low,[1] because important vaso-motor centres of the medulla oblongata are disconnected from their peripheral nerves; but the important vaso-motor centres at the lower border of the cervical portion still perform their function, for, as already observed, the incision is made high up in the neighborhood of the atlas. Now I have completely extirpated the cervical portion of the cord, from the medulla oblongata down to the fifth cervical vertebra. Such an operation causes some hemorrhage, in spite of all precautions; the animal suffers from this hemorrhage; but the influence on the blood-pressure is trifling. But if I continue this extirpation down to the first dorsal vertebra, the blood-pressure sinks suddenly to an extremely low level (about 20 mm. mercury). But the circulation still continues. Yet, as soon as I proceed with the extirpation beyond the first dorsal vertebra, the blood-pressure falls to nearly zero, and soon the heart-beats cease.

That it is really the accumulation of the blood in the abdominal viscera which causes death, can be demonstrated by an experiment which we also owe to C. Ludwig, and which, it seems to me, is of the greatest practical importance. If we knead the abdomen vigorously at the time when the heart-beats are about to cease, these immediately become more energetic. For by this kneading a portion of the blood which has accumulated in the abdominal veins is forced (by the pressure of the hands) into the heart, and the action of the latter is excited. A knowledge of this procedure is important for the physician, because, even in the case of a severe hemorrhage, he can strengthen the pulse again, if it has become thready, by kneading the

[1] From about 150 mm. mercury, the normal height, it sinks to about 60 mm. mercury.

abdomen. In cases, therefore, where the abdominal viscera are normal and where there is no damage likely to be caused by vigorous kneading; where, furthermore, everything depends on a speedy, even though passing, assistance; in such cases, I say, the introduction of even small quantities of blood, which are under all circumstances present in the abdominal veins, may be of considerable value. There are instances of hemorrhage in which the individuals can recover of themselves by the substitution of lymph, if we only ward off the momentary danger of death immediately after the hemorrhage.

I have already remarked that, when the extirpation of the spinal cord proceeds beyond the upper dorsal vertebræ, the pressure falls to zero and the heart-beats cease. But this only holds good for adult animals. I have extirpated the entire spinal cord of young dogs (about two months old), and yet the circulation continued (during uninterrupted artificial respiration), so that I was enabled to note the pressure, although it was exceedingly low (about 10–15 mm. mercury).

The hyperæmia of the abdominal viscera which is produced by paralysis of the vaso-motor nerves is an active one. Now I have already said that an active hyperæmia involves an acceleration of the blood-current in the hyperæmic district. But we must consider here that the hyperæmia is of vast extent, involving as it does *all* the abdominal viscera. The moment this great reservoir becomes widened, the blood must flow in more rapidly, else how is it possible for the tension in the aorta to suddenly decrease? But, when the reservoir is filled, the heart becomes poor in blood. The right ventricle is inadequately supplied; little blood flows into the left ventricle; only a small amount of blood is forced into the aorta. Consequently the rapidity of the arterial blood-current in general must be decreased, and it may sink to zero. For, if the heart forces no blood at all into the aorta, the circulation stops.

I call the active hyperæmia which is produced by paralysis of the vaso-constrictors a *hyperæmia of paralysis*, in contradistinction to the hyperæmia caused by irritation of the vaso-dilators, which I have termed *hyperæmia of irritation*. The hyperæmia of irritation and the vaso-dilators, respectively, were discovered by Claude Bernard in 1858. Claude Bernard[1] has shown that the submaxillary gland of the dog acquires a bright-red color by an irritation of its nerves, and that, at the same time, the blood which flows from the incised vein of the gland is of a brighter red, and more abundant, than it was before the irritation. At a later period, Eckhard[2] found similar vaso-motor nerves supplying the corpora cavernosa of the dog's penis; and, still later, Goltz[3] discovered them in the sciatic nerve of the dog. But in this nerve they lie adjacent to their antagonists, the vaso-constrictors. Accordingly, when we irritate the sciatic artificially, both kinds are acted upon, and the effect is, as a rule, insignificant, or altogether fails to appear. Special circumstances are required by means of which one of the antagonists—in this instance the constrictors—may be made ineffective.[4]

This is the case if we first divide the sciatic and make the chief experiment several days later. If, several days after the division, we draw the peripheral stump out of the wound and irritate it, we learn that the irritation excites only the vaso-dilators; the corresponding paw immediately becomes warmer, and cools off again as soon as the stimulus ceases. But I must observe that this experiment, performed on dogs other-

[1] Leçons, Système nerveux, 1858.
[2] Beiträge zur Anatomie und Physiologie, Bd. III. 1863.
[3] Pflüger's Archiv, 1874, Bd. 8.
[4] These circumstances have been ascertained by Ostroumoff, a pupil of Heidenhain (Pflüger's Archiv, Bd. 12), and by myself.

wise healthy, is not very convincing. For, if we divide the sciatic, the corresponding paw becomes actively hyperæmic (on account of the paralysis of the constrictors). But this hyperæmia of paralysis lasts a long time, because all the constrictors for the paw are already united in the sciatic. It is even questionable whether such a hyperæmia is recovered from at all in older animals. At all events, the hyperæmia is still very marked on the third and fourth days after the division of the sciatic. Accordingly, irritation of the dilators accomplishes but little if the vessels are already very wide.

But if we wait several weeks before irritating, the nerve in the mean time completely degenerates. I, therefore, make the experiment as follows: I chloroform a young dog, and then divide his spinal cord in the region of the last dorsal vertebra. Both hind-paws are now hyperæmic; but this hyperæmia improves in a few days, because the hind-legs and the sciatics respectively receive also vaso-constrictors from the dorsal portion of the cord, through the sympathetic.

I have designated this recovery as "*recovery by collateral innervation;*" using the term "*collateral,*" because the condition is analogous to a collateral circulation. If in any region the main channel of the blood is ligatured, a lateral channel, which is sufficient for the nutrition of the entire region, is gradually formed by the dilatation of small lateral branches. These small branches must, therefore, adapt themselves to their new function by increased growth. Now we see a similar condition of things in the case of the nerves.

In the region of the last dorsal vertebra, the spinal cord contains the main mass of the vaso-constrictors for the paw. These are now divided, and the remaining branches, which leave the main mass above the site of incision, do not at first suffice to maintain the tone of the bloodvessels. But these higher branches increase in strength in the course of a few days, and thus the hyperæmia disappears. I have advanced the following proof for this interpretation: After the hyperæmia of the paw has disappeared, I again anæsthetize the dog, and then again divide the spinal cord, but higher up, in the neighborhood of about the fourth and fifth dorsal vertebræ. Thereby the hind-paws once more become hyperæmic. But if an incision through the dorsal portion can now still cause hyperæmia of the hind-paws, then the tone of their bloodvessels, after the first healing, must absolutely have depended upon nerves divided by the knife in this (higher) region; upon nerves which left the spinal cord above the site of the lower (original) incision.

I now return once more to the argument regarding the vaso-dilators of the sciatic. I have divided the spinal cord in the region of the last dorsal vertebra, and have waited until the hyperæmia of the hind-paws has disappeared again. I now divide the sciatic; this can be done without anæsthesia, because the hind-legs of the animal are insensitive. Just after the division, however, the corresponding paw becomes warm again, because now also those constrictors are divided which caused recovery by collateral innervation. But even this hyperæmia improves, especially in winter, if the animal is kept in an unheated room.[1] If, now, I provide the paw in question with a suitable thermometer,[2] and wait until the mercury stops rising, open the wound on the thigh, draw out the peripheral stump of the sciatic, and apply an electric stimulus (by means of moderately strong induction-currents), the column of mercury soon begins to rise. In such cases I have observed rises of temperature from 20° to 37° Celsius [68° to 98°.6 Fahr.]; and, indeed, the rise begins a few seconds after commencement of the irritation, and, if the latter be sufficiently strong, reaches its maximum in a few minutes. Several minutes after stoppage of the irritation, the mercury begins to fall.

[1] I do not know the cause of this improvement. At all events, I must mention that I performed these experiments on quite young animals, in which, as already remarked (page 15), a certain tone of the bloodvessels is maintained, with or without any innervation. Since the recovery indicated in the text does not take place in animals whose spinal cord is intact, I suspect that in animals sick in consequence of division of the spinal cord, the blood-pressure is below the normal, and that the vessels can thus acquire their tone again more readily. But this explanation is neither sufficient nor satisfactory.

[2] Short, cylindrical, mercurial thermometers are introduced between the toes.

In consequence of these observations, we may conclude that in the sciatic there are both constrictors and dilators. I shall, however, repeat the entire train of thought which leads to this conclusion. In consequence of the presence of constrictors, the paws become warm when we divide the sciatics. In consequence of the presence of both constrictors and dilators, moreover, the irritation of the peripheral stump, immediately after the division, is without effect. If there were only constrictors present, their irritation would necessarily cause a narrowing of the bloodvessels, and hence a cooling of the parts; but this does not take place, or does so only in a slight degree. We therefore conclude that there are also antagonists (dilators) present, which are likewise irritated, and that hence no effect is produced. And we furthermore suspect that, after the division, the constrictors either degenerate or lose their irritability sooner than the dilators, wherefore the stimulus is now responded to only by the dilators. However, this proof is not altogether reliable. One could reply that the sciatic possesses no vaso-dilators; that the constrictors are only not irritable, immediately after the division of the sciatic; that on this account, and not because antagonists are present, is the stimulus ineffective. After a few days, however, the constrictors undergo some alteration, and now act in a manner quite different from that of their normal condition.

This objection is not plausible; but it is admissible. Now the hypothesis concerning the vaso-dilators is of the greatest importance for pathology. We *must* take this hypothesis into account, and it is therefore important to bring forward direct proof of the existence of vaso-dilators in the sciatic. I have, indeed, succeeded in so doing. I found that those posterior spinal roots which entered the sciatic directly, also contained the direct vaso-dilators (see page 12) for the paw, but no vaso-constrictors. Here, therefore, I had nerves before me, the irritation of which in a fresh condition, immediately after their division, caused dilatation of the bloodvessels.

In order to make this experiment, I likewise first divide the spinal cord in the region of the last dorsal vertebra, and let the animal live until the hind-paws again become cool. Then, without narcotizing the animal, I can break open the lumbar vertebræ and expose the spinal roots to such an extent that I can easily divide and irritate them. In these parts the animal is perfectly insensitive; it takes food from the hand of the attendant while I am dividing the nerves. I employ mechanical irritation by means of the application of ligatures, because electrical irritation of nerves which lie in such proximity to the spinal cord, that is to say, in such proximity to many other vaso-motor nerves, is uncertain, affecting also the other nerves, and, therefore, not giving distinct results. Mechanical irritation, on the other hand, practised with care and by steady hands, is entirely reliable. In fact, all the experiments which I have made in this direction during a series of years have uniformly given the same result. There have always been either one or two roots of the sciatic[1] which have contained the main mass of vaso-dilators, the mechanical irritation of which has accordingly produced a considerable elevation of temperature in the corresponding paw.

The fact that vaso-dilators are contained in the posterior sensory roots is not of small importance for the doctrine of hyperæmia. We are thus enabled to explain a series of important pathological phenomena.

It is known that neuralgias are frequently accompanied by hyperæmia of the painful parts. Now this phenomenon is understood if we know that the sensitive spinal roots contain vaso-dilators. Irritation of certain sensory roots must necessarily cause pain and hyperæmia at the same time. Pain and hyperæmia must also coincide as regards location in the case of such an irritation. For we locate the painful spot at the peripheral end of the nerve the trunk of which is irritated, while at the same spot the vaso-dilators

[1] Wiener mediz. Jahrbücher, 1877–1878.

which accompany the root of that sensitive nerve are distributed. Furthermore, it has become known by the researches of Baerensprung,[1] which have since been frequently corroborated, that in herpes zoster the intervertebral ganglia are diseased. Since the intervertebral ganglia are situated on the posterior sensory roots, and since, moreover, I have likewise caused hyperæmias by an irritation of these ganglia, this discovery of Baerensprung is easily understood. It is quite comprehensible that neuralgia and an inflammatory eruption may be connected with a pathological process in the intervertebral ganglion.

This fact of the common course of sensory and vaso-dilator nerves is finally suited to explain the connection between local inflammatory irritation on the one hand, and the inflammatory hyperæmia and the pain which accompany the process on the other. It was formerly supposed that the inflammatory irritation, inasmuch as it implicated the sensory nerves, caused pain by means of their centripetal conduction, and at the same time excited reflex action. Accordingly, it was said, inflammatory hyperæmia is produced by reflex action. But this assumption had no solid foundation. If every inflammatory irritation must first be conducted to the central nervous system in order to produce hyperæmia (by reflex action), I cannot see why this hyperæmia appears just where the irritation acts. If powerful irritation produces reflex action, the reflex movements are not confined to the seat of the irritation. But inflammatory hyperæmia always appears at the seat of irritation only. "*Ubi stimulus ibi affluxus*" is the old rule, which holds good for weak as well as for powerful inflammatory irritation. It is therefore probable that inflammatory hyperæmia is a direct local consequence of the local irritation. It is probable that the local irritation excites at the same time both the sensory nerves and the vaso-dilators of the implicated region. Whilst the former cause pain by means of centripetal conduction, the latter produce a dilatation of the vessels by means of centrifugal conduction.[2]

Hyperæmia of Irritation and of Paralysis.

Hyperæmia of irritation is distinguished from hyperæmia caused by paralysis of the constrictors, in the first place, by its duration. The hyperæmia of irritation lasts but a few minutes after the irritation. Experiment teaches us that the organs, after interruption of the irritation, soon become pale again. The hyperæmia of paralysis, on the other hand, lasts until the vessels have again acquired tone, and this may require several days or weeks, according to the number of paralyzed nerves. More than that, as already remarked (page 16), I consider it questionable whether hyperæmia of paralysis can be recovered from at all in older animals, and after division of all the constrictors. Meanwhile we must not consider every prolonged hyperæmia as one caused by paralysis. If, as in the case of inflammatory foci, the irritation continue, the hyperæmia of irritation can also continue. It is, moreover, possible that vessels which remain very widely dilated for a long time, in consequence of repeated or lasting irritation, can become narrower again only slowly and gradually.

Observations on man permit us to suspect that the hyperæmias of irritation

[1] The literature of this subject may be found in Kaposi's article, Zur Aetiologie des Herpes Zoster. Wiener mediz. Jahrb. 1876, S. 55.

[2] A problem as yet unsolved is the hyperæmia which accompanies keratitis. The cornea has sensory nerves; it may, therefore, also have vaso-dilators. But we should have to assume that these vaso-dilators penetrated the cornea with the sensory nerves, and did not terminate there, but returned to the vessels of the margin. For this, however, we have as yet no proof.

also play an important part even in health. The flushing of the face which accompanies outbreaks of anger is probably a hyperæmia of irritation. For, at the same time, the nerves of the muscles of the trunk also become stimulated; excited persons gesticulate violently, and contract the muscles of the face, and of speech. The glandular nerves also become excited, for in great passion the secretion of saliva is increased.[1] Finally, this circumstance is still to be considered, namely, that the hyperæmia diminishes as soon as the person calms down.

The hyperæmias which are associated with the functions of organs we may also presume to belong to this class. Respecting the salivary glands, we know that irritation of the glandular nerves (discovered by C. Ludwig) always causes an active hyperæmia, and, at the same time, an increased secretion. But I have already remarked that this hyperæmia is produced by vaso-dilators. It is accordingly most plausible to suppose that the hyperæmia which is associated with the function of glands in general, is a hyperæmia of irritation. For the other organs, it is true, we have no such positive data as in the case of the glands. But it is more probable than an irritation of the dilators is connected with the function of an organ (which requires stimuli in order to perform this function), than that a paralysis of the constrictors is associated with that function or with such stimuli. That the erection of the penis is produced (according to a discovery of Eckhard) by irritation of vaso-dilators, I have mentioned previously. According to our present knowledge, it is, therefore, not improbable that all passing, active hyperæmias which arise normally in life, and many pathological fluxions, are caused, not by paralysis of the constrictors, but by irritation of the dilators.

The Mechanical Hyperæmias.

It is an open question whether hyperæmias can arise without vaso-motor nerves being concerned in their production. The various forms of hyperæmia due to mechanical causes, which have been enumerated by pathologists, cannot be advanced as an argument here. Physicians have named the various forms of hyperæmia after their causation and their phenomena; they have not at all taken into account whether vaso-motor nerves are implicated or not, especially because they have had no knowledge, or very inadequate knowledge, of these nerves. However, in one direction, physicians have properly judged of the mechanical conditions. The ultimate cause of all hyperæmias of stagnation and of paralysis, is of a mechanical nature. If the blood does not press on the walls of the vessels, these relaxed and paralyzed walls cannot become filled and dilated.[2] It is still undecided whether the blood-pressure alone can dilate the vessels while they retain their normal tone, *i. e.*, while they are not relaxed. As far as we have, until now, been taught by experiment, this question must be answered in the negative.

In conclusion, let me remark that sometimes the hyperæmia is ascribed to increased blood-pressure, even when there is no proof of this increase. So in the case of collateral hyperæmia. It is true that the occlusion or ligature of an artery effects a dilatation of the bloodvessels in the neighborhood; but it is not demonstrable that the increased blood-pressure is the cause of the dila-

[1] In the dialect of the common people, the phrase "Der Geifer rinnt ihm aus dem Munde vor Zorn" (he foams at the mouth with rage) is very commonly employed. The same phenomena as those mentioned in the text are presented in a more marked degree in cases of maniacal delirium.

[2] I remind the reader that an active dilatation of the vessels only occurs in hyperæmia of irritation.

tation. If we ligate the femoral artery of a dog, the blood-pressure rises only temporarily. This rise is a consequence of the irritation applied to the nerves of the artery; the irritation produces a reflex act; the rise of pressure is the result of reflex action. If, before the operation, we inject sufficient hydrate of chloral into the veins of the animal to destroy the reflex excitability, the ligature of the femoral no longer produces a rise of pressure. But the rise of blood-pressure after ligature of an artery continues so short a time that it is impossible to regard it as the cause of the collateral hyperæmia. The immense dilatation of the vessels must accordingly be due to other causes; the innervation of these vessels must be altered to make them dilate to such a degree, and to so thicken their walls, that capillaries become transformed into small arteries and veins. A similar, though not so marked, an instance, is the case of *venous reflux*. If the blood from the artery cannot penetrate the capillaries, on account of an obstruction (*e. g.*, an embolus), then this capillary region can become filled from the direction of the veins, as was first shown by Virchow, and a hyperæmia can be produced which is very similar to the hyperæmia of stagnation. Now it is conceivable that we have to deal here with mechanical principles merely. If no blood enters from the arteries, then the pressure in the capillaries, it is supposed, equals zero, and the least pressure in the neighboring veins is sufficient to force the blood back into the capillaries. But, after all that we know of the dilatation of vessels, it is not probable that the feeble pressure which is present in the small veins is sufficient to dilate the capillaries. If this were possible, the capillaries could not at all retain their normal diameter under the variable influence of the arterial pressure to which they are ordinarily exposed; they would have to undergo an immense dilatation under normal circumstances. An experiment performed on the spleen, by Bochefontaine,[1] is reported to have shown that the venous reflux (congestion) is absent when all nerves are pushed aside before tying the splenic artery; that is, when only the artery, and not also the accompanying nerves are tied. In concluding this section, it may not be out of place to mention that simple hyperæmia of stagnation depends solely on mechanical causes. Nevertheless, we do not know but that the vaso-motor innervation is also changed, and that the dilatation of the vessels is produced in this way.

Consequences of Hyperæmia; Œdema and Hemorrhage.

In order to appreciate the consequences of hyperæmia, we must once more consider the capillary walls. The contractile cells have a peculiar condition of aggregation. They are not fluid, but nevertheless their parts move among each other as though they were fluid. If we watch a pigment granule in an amœboid cell, we see that it changes its position in the cell almost constantly. If, furthermore, we watch with a high power the so-called coarsely-granulated, white blood-corpuscles of the frog, we soon observe that the coarse granules are not stationary; they alter their relative positions, and also their shape. If we accurately fix upon a granule, we see, in addition, that it does not present a constant appearance. A granule may become a fine thread; the thread may disappear completely; it may perish in the hyaline basis-substance of the cell, in which the granules are apparently imbedded. In other places new granules appear. This phenomenon can be seen readily with a No. 15 lens of Hartnack. On the other hand, a still more powerful lens[2] (No. X of

[1] Archives de Physiologie, 1874, p. 698.
[2] Claimed to correspond with No. 24 Hartnack.

Seibert and Kraft) permits me to recognize a continual inner movement in the white blood-corpuscles of man, even if they are externally at rest. Immediately after the specimen of blood is taken from the finger, the white globules look like little lumps; their external contour does not change. But though the external contours remain unchanged, the new lens teaches me that there is a continual displacement of the mass in the interior. On a brighter background we see an irregular dark picture, with contours which are at times clear, at times ill-defined; and this picture changes uninterruptedly. The whole makes an impression similar to that of the transformation of light and shade in a cloud. I shall call this motion an *internal flowing motion*. Only at a later period (perhaps under the influence of stimuli to which the blood-corpuscle is exposed on the slide), does it commence its amœboid movements, does it change its external form and its position.

Much more striking are the internal movements which the lens X (Seibert and Kraft) shows in the salivary corpuscles. It was known long ago that granules which had a swinging motion existed in the salivary corpuscles. A No. 8 lens of Hartnack permits one to see these distinctly. These movements were called molecular—because they are similar to those observed with high powers in the case of finely divided granules[1] suspended in water. The No. X lens has taught me, however, that in the salivary corpuscles there are no granules at all. The salivary corpuscle is traversed by a sharply defined network, which is in continuous, undulating motion. Single trabeculæ of this network are seen, as though in transverse section, and thus simulate granules. If we watch a salivary corpuscle until it bursts, we find that, the moment it bursts, the undulating motion of the net ceases. But all the salivary corpuscles do not burst; in some, the undulation gradually becomes feebler without their rupturing, and just these moments of enfeeblement are suited to demonstrating, with the greatest precision, the existence of the undulating net. I shall call this motion the *internal undulating motion.*

Experiments of Recklinghausen have already made known the fact, that by the addition of water to a lymph corpuscle we can produce a body resembling the salivary-corpuscle. The salivary-corpuscle, on the other hand, again becomes an amœboid body, by the addition of a solution of salt from a half to one per cent. in strength. Now I have lately discovered that, by the addition of water[2] to the white blood-corpuscles, an undulating net appears, just like the one present in salivary-corpuscles—a net whose undulation ceases with the rupture of the corpuscles. Accordingly, the externally quiescent salivary-corpuscle differs from the externally quiescent white blood-corpuscle only in the character of the internal motion. One kind (the flowing) can be converted into the other (the undulating). If the white blood-corpuscle has been converted into a body similar to a salivary-corpuscle, by means of carefully diluting its medium with water, then the internal flowing displacements of the mass cease, and in their stead we have the undulating movements. The undulating net forms standing waves, as it were. The network remains constantly, beams remain beams, meshes remain meshes, even though the whole sways to and fro. If, on the other hand, the salivary-corpuscle becomes an amœboid cell, then the undulating motion ceases, and the slow internal flowing begins. As long as only the motion of these apparent granules was known, the question was discussed, whether it was a vital motion. On the ground of his electrical experiments, Brücke[3] argued in favor of their vital

[1] Wrongly called molecules by the older biologists.
[2] The water must be added very carefully. Still better than water is a very dilute solution of salt—say about $\frac{1}{10}$ per cent.
[3] Wiener Sitzungsber., 1862.

nature, and now there can no longer be any doubt regarding the correctness of this view.

We already deduce from these observations, that the contractile bodies can alter their physical condition very quickly. If now we also remember that contractile cells alter their consistence with increasing age; if finally, I repeat once more (reserving the proof until later), the more resistant cells of older animals return to their youthful condition in the inflammatory process, it becomes comprehensible with what variable structures we have to deal here. In the case of the isolated cell, in the pus- lymph- salivary-corpuscle, the rapid temporary change is produced by influences in the surrounding medium. In the cells of glands, similar changes are excited by nervous influence. As soon as the cell in the gland begins to enlarge under the influence of either direct or nervous stimuli, its internal mass begins an active flowing motion. Accordingly, if we say that the capillaries are contractile, we must not conclude that they always retain the same physical properties. We have rather cause for supposing that under the nervous influence not only the thickness of the wall and the lumen of the tube, but also the physical structure of the wall, becomes changed. The striped muscular fibres, moreover, give us evident proof of this. In a condition of contraction the muscle is hard; in a condition of relaxation it is soft and doughy.

Now, inasmuch as hyperæmia is accompanied in many if not in all instances by a change of innervation, it is clear that from this standpoint, already, an alteration of the wall of the vessel can arise in its train. But alterations of the walls of vessels are of influence on the mutual relation of blood and tissue. The capillaries are the main channel for the nutritive current, and the dimensions of this current certainly depend, *cæteris paribus*, on the physical properties of the vascular wall. But apart from the innervation, we must consider the influence of the coarser mechanical effects on the wall of the vessel. During dilatation, the walls of the capillaries must become thinner and better adapted to filtering than normally. Coincidently with the dilatation of the capillaries, the blood-pressure also doubtless rises in them,[1] and it is self-evident that filtration is promoted by the increased pressure. As long as the vessels are normal, these mechanical influences are perhaps of minor importance. But in the case of prolonged hyperæmias, these prolonged, though slight, influences also gradually produce changes in the vascular walls.

Finally, in hyperæmia, we must consider the influence which the changed composition of the blood exerts on the vascular wall; namely, the pronounced venous character of the blood in hyperæmia of stagnation and in venous reflux, and, again, the abnormally arterial character of the capillary blood in active hyperæmia. In this respect it is worthy of mention that hyperæmias of stagnation are never or only seldom followed by inflammation (at least not directly), but by *œdema*, *hemorrhages*, and (in the case of circumscribed stasis especially) *migration*. There is no better means of demonstrating migration than by producing stasis in a small vascular district. If after a short time the stasis disappears, the wall of the vessel looks as if strewn with blood-corpuscles, many on the point of passing through. Above and below, to the right and to the left, they are suspended, and we can easily observe all phases of their passage. This circumstance also led me to the discovery of diapedesis in 1865. For at that time I covered the tails of curarized tadpoles with thin covering-glass; and the pressure of the covering-glass is

[1] Only in the capillaries and veins, not in the large arteries. Here the pressure can fall, for example, from 100 to 50 mm. mercury, whilst in the capillaries it may rise from 10 to 30 mm. mercury.

sufficient in the case of tadpoles to cause stasis and migration. In the fully-developed frog this is not produced so quickly. In the mesentery of that animal, we must continue the stasis several (as much as twenty-four) hours, in order to be sure of obtaining a view of the migration of corpuscles.

Active hyperæmia can lead to œdema under special circumstances, yet well-marked œdema does not belong to the regular consequences of active hyperæmia. More frequently metamorphoses of tissue arise which must be regarded as commencing inflammation. True, we are taught that simple hyperæmia does not lead to inflammation; that the appearance of inflammation presupposes the existence of another cause besides that of hyperæmia. In fact, we must admit that temporary hyperæmias do not produce any marked alterations in normal tissues. But when the normal condition has been disturbed—when, for example, an organ has just passed through an inflammatory process—then moderate hyperæmias, such as accompany a moderate exercise of function, suffice to re-excite the inflammation. This is partly the reason why physicians are inclined to keep at absolute rest, during a considerable period, organs which have been inflamed, since a hyperæmia accompanies the exercise of function in the case of every organ (see page 19), and hyperæmia favors relapse. On the other hand, it seems that frequent and prolonged hyperæmias can very well cause hypertrophies and chronic inflammatory tissue-metamorphoses. I say it seems, because, in all cases where tissue-changes arise (even if they are only simple hypertrophies), one can say it was no simple hyperæmia.

Cardinal Symptoms of Inflammation.

Since the time of Celsus, the following have been regarded as the cardinal symptoms of inflammation, namely: Heat, redness, pain, and swelling. In modern times, another sign has been added—that of impaired function. I believe, however, that we would do well to discontinue this mode of characterizing the process and adopt another. Inflammation is characterized by two features: (1) by an active hyperæmia, and (2) by an active tissue-metamorphosis. I call these changes *active* because the tissues take part in them as living constituents of the organism; as living masses. If an active hyperæmia occurs alone, we can evidently not call it inflammation. If the active metamorphosis of the tissue arises alone, without a trace of hyperæmia, we again do not speak of inflammation, but of a new formation.

Active hyperæmia, when situated in the skin or in superficial mucous membranes, causes redness and increase of temperature, the latter having evidently suggested the name "inflammation." The older physicians did not clearly understand that the increase of temperature could be produced by an accelerated circulation, that is to say, secondarily. They pictured to themselves that something must be burning in the part affected. *Febris* (from *ferveo*) and *Inflammatio* were therefore allied diseases for them. Inflammation, it was said, was local fever. In the case of fever it has now been ascertained that it is accompanied by an increased production of heat. But for inflammation this is not positively determined. It is possible, and even not altogether improbable, that the active tissue-metamorphosis of inflammation is accompanied by an abnormal local production of heat; but it is not proved. Accordingly, all that can be considered as positively established is that *the elevation of temperature of inflamed regions of skin is due in great measure to the hyperæmia; to the accelerated blood-current.*

What I said previously (page 2) in regard to the heating of the tissue by the blood-current had reference only to the external skin and super-

ficially situated mucous membranes, that is, to parts which are in contact with the atmosphere, and, according to the protection which their position offers, cool off more or less if they are not heated by the blood-current. Whether a more deeply situated organ—the kidney, for example—cools off when little or no blood flows into it, we do not know; for the internal organs have the temperature of the blood, and a mass relatively as small as the kidney could be kept warm by its surroundings even if no blood flowed into it. Hence it seems expedient to omit the symptom "heat" altogether from the definition of inflammation, and in place of both *heat* and *redness* to put simply "*active hyperæmia*," or "*fluxion*."

The symptom *pain* is also not always met with. Not all organs are painful when inflamed, though no doubt it seldom occurs that inflammations run their course painlessly. But we must remember that in the neighborhood of less sensitive organs (parenchyma of the lungs, for instance), there are as a rule very sensitive parts, which cause pain when they are in the slightest degree implicated. Thus the pleura, covering the lungs; the meninges, the surface of the brain. Of itself, therefore, pain is not generally a trustworthy symptom of inflammation.

The same may be said of the symptom *swelling*. We are not sure whether the bones, for example, necessarily show an externally visible swelling in inflammation. I must remark right here that inflammatory swelling is distinguished by its hardness, and in many cases the hardness, not the visible swelling, is the decisive characteristic. If I see a reddened district in the skin; if I palpate, and find it hot and hard; I say it is inflamed, even though no swelling be visible. And it is, indeed, possible, that the swelling at times may become unrecognizable, as for example when the inflammation is seated in a nodular, uneven neoplasm. The inflammatory swelling and hardness are, as I shall show, dependent on the active tissue-metamorphosis. I say, therefore, that the tissue-metamorphosis is a generally reliable symptom, and put it in the place of swelling.

The active tissue-metamorphosis likewise includes the symptom *impaired function*, for I shall show that the tissues when undergoing inflammatory changes have their function impaired. But this change is a gradual one. A muscle can still contract at the commencement of inflammation, when the tissue-metamorphosis has already begun, and can be recognized under the microscope.

General Remarks concerning the Inflammatory Changes of Tissues.

The inflammatory changes of tissues may be described in a few words. As soon as an inflammation occurs, the tissues return to their embryonic state. In the embryo, the entire organ consists of amœboid cells. The inflamed tissue of older animals, which is normally composed of more rigid cells and intermediate substance, is again converted into amœboid cells, or, I should prefer to say, into *amœboid substance*, in view of my most recent researches. The subdivided amœboid substance, or the amœboid cells of an inflammatory focus, are called *pus-corpuscles*. It is accordingly the tissue itself which is transformed into pus-corpuscles.

Although I am writing here in the interest of practical branches, I cannot desist from advancing the reasons for this theory. I must show its relation to older theories, and what reasons have influenced me in discarding the older theories and especially the migration theory. But this explanation is only possible if I give the reader a sketch of general histology. If we desire to become acquainted with the processes which occur in any apparatus (Einrich-

tung) we must possess information regarding the apparatus itself. This sketch of general histology will likewise be in place here, inasmuch as it will also include the doctrine of growth and nutrition of the tissues, as well as the doctrine of regeneration and cicatrization.

Historical Remarks concerning the Theory of Inflammation.

From about 1855 down to 1867, Virchow's theory of inflammation, the so-called suppuration-theory, was almost universally accepted. The pus-corpuscles were said to be formed from the connective-tissue cells. At first the nuclei of the cells, and then the cells themselves, were supposed to subdivide, and by means of these subdivisions the pus-corpuscles were believed to be produced. In the year 1867, Cohnheim[1] contradicted this theory. The pus-corpuscles, he said, are migrated white blood-corpuscles. This assertion was partly based on a study of the inflamed cornea, stained with gold. In spite of the fact that the inflamed cornea appeared filled with pus-corpuscles, the cornea-corpuscles were, as he asserted, entirely unaltered. The source of the pus-corpuscles had, therefore, to be sought elsewhere than in the cornea-corpuscles. The branched cornea-corpuscles, Cohnheim said, are fixed cells; they change neither their locality nor their form. The pus-corpuscles, on the other hand, are amœboid; they change their position and their form. It was known, long before this, that the pus-corpuscles were similar to the white blood-corpuscles, and that the white blood-globules were amœboid, and it was therefore natural to consider them identical. In addition, Recklinghausen now made the discovery that amœboid cells could migrate into the lifeless cornea, and wander about in its tissue.

Now, stimulated by my discovery of the diapedesis of red blood-corpuscles, Cohnheim and Hering (independently of each other) came to the conclusion that white blood-corpuscles could also migrate. Cohnheim observed the migration in the mesentery of the frog, after exposure to the air. The influence of the air could be regarded as an irritation capable of producing inflammation. In such cases the mesentery soon became covered with amœboid cells. Accordingly, we had before us inflammatory products, pus-cells; one was therefore apparently justified in saying, "Here is inflammation; and the products of inflammation, the pus-corpuscles, originate from the blood." Whether the changes in the expanded mesentery were really to be regarded as inflammation and suppuration, or not, was indeed not known. First of all, the most important sign, the inflammatory hardness, was missing. Moreover, nobody had observed a destruction of the tissue, by suppuration, in the spread out mesentery. Finally, only a migration *out* of the vessels of the mesentery was known. Whether in the case of keratitis wandering cells really passed *into* the cornea, was not known. But the boldness with which Cohnheim positively affirmed that the cloudiness and suppuration always began on the borders of the cornea, even if it was injured in the centre, gave his theory a substantial support; for such an observation would speak directly in favor of the fact of the pus-corpuscles penetrating the cornea from without (from the periphery).

Then came the experiment of the so-called "feeding of the cells." If we introduce finely divided coloring matter (cinnabar, aniline) into the circulation of the frog, the granules of pigment are absorbed by the white blood-corpuscles within the general circulation. If we now examine a drop of blood, we shall see amœboid cells containing granules of pigment. If we

[1] Virchow's Archiv, Bd. 40.

excite a keratitis after the injection of the coloring matter, and cut out the cornea when the inflammatory process is at its height, we shall also see, in occasional instances, similar amœboid bodies which contain pigment granules.

Now if the cornea-corpuscles do not become changed in inflammation, and do not generate pus-corpuscles; if the pus-corpuscles always penetrate the cornea from the border, where the bloodvessels are situated; if the pus-corpuscles are similar to the white blood-corpuscles; if the white blood-corpuscles really migrate, who would doubt any more that the pus-corpuscles originated from the blood? However, in the year 1869,[1] I had already found out, in conjunction with W. F. Norris, that Cohnheim had examined the cornea imperfectly; that the cornea-corpuscles in fact did change; that their nuclei increased; that they became amœboid in the course of the inflammatory process. True, we said, they do not all change at once; they do not change everywhere in the entire cornea, but only where a centre of suppuration is forming. But in the rest of the cornea we see the old cornea-corpuscles at the side of single new cells which look like pus-corpuscles. But inasmuch as at that period we likewise could not observe movements in the branched cornea-corpuscles (in their normal condition);[2] and inasmuch as we had learned that they became amœboid (like white blood-corpuscles) during inflammation, we said that the newly-formed corpuscles had passed into this neighborhood, and had become visible beside the unchanged branched cornea-corpuscles. Norris and I have furthermore shown that the suppuration does not always begin at the edge of the cornea, as Cohnheim asserted, but that it begins *where the irritation has exerted its influence.*

Finally, we have shown that the experiment with the pigment is no argument in favor of the migration theory. After the injection of coloring matter into the blood, pigment-granules can also be found in the branched (supposed fixed) cells. Therefore, the presence of pigment-granules in the amœboid cells of the cornea cannot be regarded as a sign of their originating from the blood. Even a single consideration teaches us how deceptive this sign is. In consequence of the inflammatory hyperæmia, an increased nutritive current flows into the focus of inflammation. The vascular wall is, as we know, permeable; red and white blood-corpuscles can pass through it; why should not the much smaller pigment-granules likewise be carried through the wall of the vessel and into the cornea, by the nutritive current? Once arrived in the cornea, they can adhere to the soft and sticky pus-corpuscles, and reach their interior.

Of the arguments in favor of the migration theory there only remained the fundamental fact, that the blood-corpuscles in general could migrate. But, as already remarked, nobody has proved that they migrate in the course of a keratitis, or that they pass into the cornea. Properly speaking, the state of the question was now as follows: It was certain that the pus-corpuscles in the cornea were produced from pre-existing elements. It was uncertain whether, in addition, pus-corpuscles penetrated it from without. I and several of my pupils had likewise observed the genesis of pus-corpuscles from the cells in other tissues, and thus, in 1869, I could already say that I knew of no tissue in which the inflammation and suppuration were to be referred solely to migration.

But at that time I laid the greatest weight upon the alterations of the capillaries. In the case of all other tissues, one might object (and the objection

[1] Studien aus dem Inst. f. exp. Path. Wien, 1869.

[2] New researches, of which I shall speak hereafter, demonstrate that these bodies, too, are movable.

has been raised) that I was deceived, that I did not prepare the specimens properly. Those parts of the inflammatory focus, it was argued, which exhibited no normal cornea-corpuscles at all, I had stained imperfectly. Where I supposed that I had seen corpuscles which had been changed by the inflammation, it was said that I had been dealing with lifeless, and therefore changed, cornea-corpuscles. Where I asserted that I had seen multi-nucleated amœboid corpuscles, produced from the cornea-corpuscles, it was argued that I had been deceived by white blood-corpuscles which had coalesced. If I spoke of an increase of nuclei, they were explained as the lifeless, broken-down nuclei of the old cells. The thickening of the capillaries, however; the sending out of new processes; the numerous nuclei which were scattered about in their walls; these were all reliable indications that inflammation was accompanied by an active tissue-metamorphosis. New bloodvessels and offshoots of the same cannot migrate.

But, in the mean time, the migration theory had been too favorably received to permit of influencing its believers with arguments. And this great favor was due, in part, to its simplicity. It was convenient for the clinical teacher and pathological anatomist to be able to enunciate the foundation of all pathological histology in a single sentence. They might say to themselves that histology was really superfluous for them. If they only knew that the white blood-globules migrated, penetrated the tissues, and appeared there as pus-corpuscles, they thought that with these few propositions they had acquired all that was of real importance.

On the other hand, the doctrine of the tissue-metamorphosis, as I shall call my theory, was at that time (in the year 1869) still in a sorry plight. I and my pupils had seen only a rudimentary portion of the metamorphosis. In principle, we had scarcely proceeded farther than Virchow's doctrine; for we did not advance more than the fact, which had been denied by Cohnheim, that nuclei and cells did divide. Only as regards the mode of division did I bring forward a new explanation, which corresponded to the state of the cell-doctrine of that time. I showed, namely, that the cell-division did not proceed as taught in Virchow's theory. For this theory taught, that at first the nucleus divided into two portions; that the nuclei moved apart; that the cell then became biscuit-shaped; that the heads of the biscuit contained the new nuclei, and then separated. I showed, however, that the cells became amœboid before division. While the cells of the completed tissue, in consequence of the methods of examination of that period, appeared to remain in the tissue unaltered; in the commencement of inflammation, I said, they again begin their independent movements. I said, *again begin*, since in the embryo this capability of motion is possessed by all cells. Therefore I likewise said, that *the cells return to their embryonic state.* I showed, furthermore, that before division the cells were doubled up into a small mass, remained quiet in this condition for a time, and then divided by cleavage. As soon as the cleavage was over, the fragments crept asunder.[1] I showed, moreover, that there was still another kind of division. I had seen cells which were torn into two pieces during their uninterrupted movements.

These observations indeed taught us how pus-corpuscles were formed out of connective-tissue corpuscles, but they opened up the disagreeable prospect that we might be compelled to examine every tissue separately in order to ascertain if and how the formation of pus proceeded in each various type. But, moreover, the theory of metamorphosis was just as little suited to explaining the macroscopical (clinical) phenomena as the migration-theory. At the bedside we do not see any pus-corpuscles with the naked eye. We

[1] Stricker's Studien, etc.

see redness and feel hardness; we learn that the hard spots in the centre soften (resolve or melt, as the old physicians called it). These phenomena were left unexplained by the one theory as well as by the other.

But the condition of affairs has now changed. In the year 1874, I began to study keratitis in mammalia, and here obtained results which explained the clinical phenomena satisfactorily. Starting from this point, I examined all kinds of tissue, and the results obtained were of such a nature that I also can now clothe the doctrine of inflammation in a simple form. *Metamorphosis of tissue; return to the embryonic condition; division into amœboid cells of the masses which have become movable; hence the destruction and the suppuration;* this is briefly the outline of my new doctrine. On the other hand, all the details of my further researches were very favorable for my theory. It appeared that this theory was in harmony with the results of researches in the domain of comparative histology and histogenesis. It appeared that in the pathological destruction of tissue by suppuration, not only the cells, but also the entire tissue, returned to the embryonic condition. The machine was, as it were, separated into its parts again. In regard to the pathological tissue, therefore, I was about in the position of the mechanic, who takes apart the machine and finds that which its builders have asserted to be present. It appeared, furthermore, that the return of the tissue to the embryonic state at the same time included the conditions requisite for a healing of the tissue. In every phase of the inflammation the destruction can cease, and a regeneration or a cicatrization can be started. And this new formation is throughout similar to the embryonic new formation. In consequence of such observations, my conviction of the correctness of my theory of inflammation has been so much strengthened that I believe that I may now venture to publish it together with all its deductions. But I must finally remark that the opposition to this theory has only been heard in modest tones during the past few years. The migration-theory has proved to be fruitless. It has made no progress since 1867, and, in regard to the doctrine of inflammation, it cannot make any progress; for it denies the active processes. But the doctrine of tissue-metamorphosis has made constant advances, and every new step which I have taken in the course of the last decade has proved to be an argument against the migration-theory.

Suppurative Keratitis.

I have obtained a better insight into the processes in the cornea by a method which has turned out to be very rich in results. At first, I apply an inflammatory stimulus to the centre of the cornea of a young cat by cauterizing with caustic potassa, or by the introduction of a foreign body—the most suitable being a thread which is passed through the centre of the cornea and the bulb with the aid of a needle, and is then tied into a knot for the sake of fixing it. When the inflammation has reached a certain height, that is, after about twenty-four hours,[1] I narcotize the animal and paint the cornea with lunar caustic until it becomes very turbid throughout. Now the animal is killed; the cornea is cut out and preserved in water slightly acidulated with acetic acid. On the following day I remove the cornea from the acidulated water and split it into lamellæ. This procedure is very easily accomplished in the case of corneæ thus treated. By the influence of the

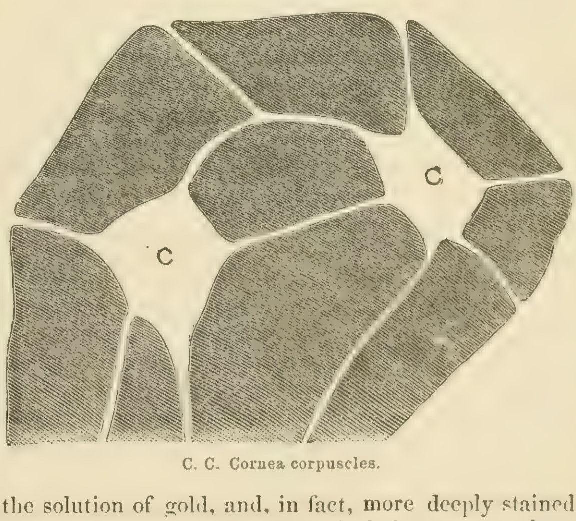
[1] Such experiments are most successful in spring. In the beginning of winter, the results are, as a rule, very bad. In our climate (Vienna), I would recommend the months from April to October for such experiments.

acid, the tissue becomes swollen, and its parts are loosened. On the other hand, from the action of the silver (perhaps coagulation), it has acquired a certain hardness. Consequently we can easily separate it into lamellæ which still possess a certain hardness. The first cleavage into two lamellæ, and then of each of these into two, I can accomplish with the naked eye. The further cleavage I perform with the aid of a magnifying glass; the method cannot be well described, but can easily be found out for himself by the practised manipulator.

Even in the lamellæ which have been stripped off with the naked eye, we can distinctly recognize, under the magnifying glass (with transmitted light), the inflammatory focus and the purulent spot respectively. On these foci or spots I concentrate my main attention during the subsequent cleavage. For little is to be gained by a fine cleavage of the normal or slightly altered spots in the neighborhood of the focus. We can obtain a view of the normal appearance even in thicker, less transparent lamellæ. But in the inflammatory focus we do not get clear and convincing pictures until we have thin lamellæ. The inflammatory foci are less translucent than the normal spots; furthermore, the accumulation of cells into heaps interferes with the examination. All of these impediments are done away with if the lamellæ are very thin. The pictures here become so clear that there can no longer be any doubt with regard to the nature of the suppurative process. Before describing these pictures, however, I must correct an error which has crept in as a consequence of the method of staining with silver.

If we stain an excised cornea in a solution of nitrate of silver, the branched cells of the cornea appear as light cells on a dark background. For the basis-substance of the cornea in which the cells lie imbedded absorbs the silver better than the cells do, and accordingly becomes stained a deep brown when exposed to daylight, while the cells remain of a light color. In fact, the cells are, as a rule, not visible at all; we only see light branched spots (spaces) on a dark ground. (Fig. 6.) Recklinghausen, who was the first one to employ this silver-staining methodically, believed that the cornea contained real spaces, and called these spaces nutritive canals (saftkanälchen). In these spaces he thought that the cells were situated, and that the amœboid cells wandered through them. At a later period, Cohnheim stained the cornea with chloride of gold, and then a different picture was presented. Anastomosing figures were also to be seen here; but these figures proved to be nucleated cells which had been stained of a violet color by the solution of gold, and, in fact, more deeply stained than the surrounding basis-substance. Accordingly, the branched figures were here dark on a light background, but in the cornea treated with silver, on the contrary, light on a dark background. Using the language of the photographers, we may say that the branched cells appear as positives after staining with gold, but as negatives, on the contrary, after staining with silver.

Fig. 6.



C. C. Cornea corpuscles.

This agreement of the forms, after staining with silver and with gold, induced me to

restrict Recklinghausen's hypothesis concerning the existence of nutritive canals.[1] There must be spaces in the basis-substance, I said, because the cells must have space to lie in; but the spaces are filled up; the cells are everywhere in intimate contact with the basis-substance. By means of the silver-staining, the cells become invisible, and the light spaces then seem empty in the dark basis-substance. The silver-staining as I perform it—namely, in the living animal—likewise colors the basis-substance darker than the cells; but the cells, too, are stained, and appear like nucleated, granulated, branched bodies, exactly of the shape of those supposed spaces which can be seen after staining with silver in the case of the *excised* cornea, and exactly of the shape of those violet cells which appear in specimens stained with gold. On the ground of these observations, I said that they were not empty spaces (filled only with fluid), through which the nutritive current passed. These spaces are filled up with cells. Moreover, an observation which I had made at an earlier period (1869, in conjunction with Norris) had, in fact, taught that in the inflamed cornea the nutritive currents circulated through the cells. I have already mentioned under what conditions we have seen pigment-granules in the branched cells. Now, in the case of the excised cornea, these pigment-granules, while under examination, passed through a process of one cell into an anastomosing process of another. But the pigment-granules can only be carried off passively by a current of fluid (nutritive current). Accordingly, I said, the nutritive current passes through the cells, and only indirectly through the spaces, inasmuch as the cells lie in these spaces.

These cells had appeared branched in all species of animals which I had examined up to that time. The processes of the various cells, I therefore said, anastomose; cells and processes form a unit—a network; the junctions of the network possess nuclei, and are regarded as cells. These junctions, I added, are not equally developed in all species of animals. In the frog and in the rabbit they are very marked. Here we in reality see cells and processes as described by authors. In certain fish which I have examined, I found only a network of finely granulated substance, whilst larger masses, which might be regarded as cells, were altogether wanting. In the cat and in the dog the facts are not the same as in the frog. Here there is likewise a more homogeneous network present,[2] only the trabeculæ of the network are much broader than in fishes. Accordingly the reticular structure is what appears to be common to all species of animals. But all of these observations were made on lifeless, stained corneæ (with the exception of the cornea of the frog). Only in the lifeless corneæ of the fish, the cat, and the rabbit, have I seen this network. What the appearances are in the living animal will be treated of on a subsequent page. For the present, I again lay stress upon the fact that we cannot recognize any structure in the normal cornea of the frog; freshly prepared in aqueous humor, it appears light-colored, glassy, and homogeneous. Only in the case of the diseased, turbid, and freshly prepared cornea of the frog do we also see such branched cells as can be made to appear by staining with silver or gold.

Let us therefore consider now only those corneæ in which we can see the network and basis-substance on account of their different color or different shading. The meshes of this network are filled with basis-substance. This basis-substance, as I have already remarked, and as I shall again emphasize here, is also living matter (during the life of the animal). For the entire cornea is a living organ, the basis-substance being of a different character from that of the cells. These two constituents react differently during life[3] to solutions of silver and of gold, and to various other solutions. Therefore we believe that we can distinguish them by staining with silver or with gold. The cells as well as the basis-substance, I say, are living matter, and at times they vary their relative positions (as is proved by the stained speci-

[1] See my Vorlesungen über allg. und exp. Path. Wien, 1878, S. 280.

[2] Nevertheless there are trabeculæ of varying thickness present. But pronounced expansions (points of junction) as they exist in the cornea of the frog are for the most part wanting.

[3] In the lifeless cornea, the staining with silver and gold prove to be very imperfect. Therefore nobody has yet, to my knowledge, succeeded in obtaining such distinct pictures of the cornea of man, as of the cornea of animals which can be stained while fresh or living.

mens). At one time the basis-substance becomes enlarged, while the cells and their processes (*i. e.*, the trabeculæ of the network) become diminished; at another time the reverse is the case. Border quarrels, as it were, take place between the network of cells and the basis-substance. One and the same strip of territory is at one period a portion of the body of a cell, or of a process; at another period, a part of the basis-substance. Here and there, also, entire cells perish, and are completely converted into basis-substance. As I shall soon show, it only requires changes of short duration to transform the basis-substance into a cell, and, *vice versâ*, a cell into basis-substance. These changes correspond on the one hand to the normal development of tissue, and on the other hand to pathological processes.

In general, we may say that the larger cells, and also a greater abundance of cells, are characteristic of a more youthful condition of the tissue. In the embryo, we see scarcely anything but cells, separated by narrow traces of intermediate or basis-substance. The older the tissue becomes, the broader are the traces of intermediate substance, and the more slender are the cells and their processes. The reverse takes place in inflammation. The more advanced is the process of inflammation, the larger do the bodies of the cells and their processes become, and the smaller are the islands of basis-substance which fill up the meshes of the network.

But it is now appropriate to describe more accurately these processes as they occur in inflammation. I proceed, accordingly, to the consideration of those microscopical observations, of which it has already been said that they are in harmony with the clinical phenomena—observations, namely, which I have made on the inflamed corneæ of young cats, examined after staining during the life of the animal.

I shall suppose that the inflammation has been excited by touching the centre of the cornea with caustic potassa.[1] If now we place under the microscope a lamella prepared according to the specified method, we easily recognize the cauterized focus. Here no pus-corpuscle, not any trace of an inflammatory process, is to be found. The cornea-corpuscles and the network respectively are still to be recognized; they present themselves as crumbled masses. Nowhere a multiplication of nuclei; nowhere an indication that there was still life in them at the time they were stained with silver, that is, at the height of the inflammatory process. It is different in the neighborhood of the slough. Here the network of cornea-corpuscles appears greatly swollen,[2] and the basis-substance in the meshes of the network diminished. Here and there the basis-substance has entirely disappeared, and the network has thereby become very much nodulated. The relation is about the same as if I should pour water on the polished surface of a table, and then spread it out with the finger into a network over the entire surface. The beams of the watery network are to represent the network of cells, the dry islands of the table the basis-substance. If now I pour on water repeatedly, the lines of water become continually increased in size, whilst the dry islands become smaller, until finally nearly the entire table is covered with great masses of water, with only here and there a dry island still visible.

If we look at the lamella with a magnifying glass while it floats about in water, we notice that in all those places where the network of cells is swollen, the lamella is swollen too. If we expose such a lamella to diffused daylight for some hours (even up to several days), we shall soon recognize with a power

[1] Best as follows: Melt caustic potassa in a silver crucible, and allow it to be sucked up by capillary attraction into very fine glass tubes. Each of these tubes may be employed to cauterize repeatedly, by breaking off the used-up point.

[2] Always in patches only; I have never seen this change in the entire circumference of the eschar.

of 200 or 300 diameters a new picture in the swollen network of cells. We see, namely, that the network of cells in the thickened region is divided into small fields by brown lines. In each of these spaces, moreover, we find either one or several small nuclei. Sometimes these nuclei are clearly defined without special preparation. But if this is not the case, we can always show them very nicely by again staining the lamella with hæmatoxylon. The nucleated spaces are cells, the brown lines are the cell-outlines.

Let us recapitulate: The lamella is here and there thickened. The network of cells is swollen. The basis-substance is reduced in extent. The cell network has become differentiated into smaller nucleated portions. Only one more step is necessary to complete the occurrence of suppuration. Whenever the basis-substance has entirely disappeared, the nucleated portions need only to fall apart, and the abscess is complete.

The swelling and thickening of the tissue is surely only the expression of the swelling of the cell-network, for the entire mass consists only of basis-substance and cell-network. But the basis-substance disappears; therefore the swelling of the cell-network only can be proportionate to the swelling of the tissue. The swelling of the cell-network must accordingly cause the thickening and induration of the tissue. I purposely make use of the term *induration* to indicate inflammatory swelling, and to distinguish it from œdematous swelling, which likewise occurs in inflammations. Inflammatory swelling (the induration) corresponds with what physicians call infiltration; with what presents itself in cutaneous abscesses, for instance, as inflammatory hardness; as nodules. I remark at once that the infiltration may not necessarily be an inflammatory one. Lupus, for example, forms analogous infiltrations, manifested as nodules, and the nodule in the one case as in the other is a preparatory stage to the destruction of the tissue. In fact, Jarisch has shown[1] that the microscopical appearances of the lupus nodule correspond exactly with what I have observed in suppurative keratitis. The infiltration accordingly consists of a swelling of the network of cells. The greater this becomes, the more rigid is the tissue.

Swelling is a phenomenon of growth. The growth of cells is of course only possible by means of the absorption of new matter, and this matter is most probably supplied by the blood, and we may well call it an *exudation*, in the sense of the older pathologists. In this sense it is admissible to say that the swelling arises from an exudation. But for a comprehension of the process it is not indifferent whether the fluid (the exudation) trickles into the tissue, or whether it is absorbed there by the growth of a branched living body. The fluid which trickles into the meshes of tissues (as, for example, into the meshes of the subcutaneous tissue in the neighborhood of an abscess), can also produce a swelling; but this is a soft, doughy swelling. On the other hand, the cell-network which has become rigid by growth, is hard and forms a nodule. Œdema can be made to disappear by pressing, but the infiltration does not give way in this manner. As a rule, too, œdema disappears as soon as the height of the process is over; the portion of the nodule, however, which does not become disintegrated (as a rule the peripheral portion), requires for its complete retrogression many days, sometimes many weeks. Finally, the œdematous spots never (directly) suppurate; a portion of the nodule on the other hand is, as a rule, doomed to destruction. Inasmuch as the basis-substance disappears; furthermore, inasmuch as the protoplasmic masses which arise from the swollen network of cells subdivide; and lastly, inasmuch as the products of division fall apart, the nodule (or the infiltration) is resolved, and the pus-corpuscles are the product of resolution.

[1] Archiv f. Dermatologie, 1880.

By the purulent destruction of tissue, moreover, not only pus-corpuscles are isolated, but also small granules, small shreds from the cell-network, and, in addition, larger pieces of tissue débris—tissue débris in which the suppuration had not yet fully ripened when its connection with surrounding parts was severed. Suppuration is therefore a process by which pus is formed. I say *pus*, not *wandering cells.* Pus, it is true, contains wandering cells, but wandering cells alone are not yet pus. Pus is composed of fluid, of wandering cells, of granules, and of tissue débris. Where pus is formed in the midst of the tissue, the tissue must be disintegrated. For pus takes up space; it fills up the cavity of an abscess; and in place of the cavity and pus respectively, there must formerly have been a tissue. The suppuration, the disintegration of the tissue, is prepared for by the inflammatory infiltration. The cells and their processes must swell. The basis-substance must disappear before disintegration takes place. Hence the inflammatory infiltration is preparatory to the disintegration of the tissue. Wherever the physician finds an inflammatory infiltration, an induration, he must regard disintegration, suppuration, as threatened. I say threatened, since the disintegration is not inevitable. In fact, the entire infiltration seldom suppurates, but generally a central portion only. The peripheral zones are for the most part preserved, and gradually return to their normal condition. For even if the network of cells is swollen, and the basis-substance reduced; as long as no disintegration has taken place, a restoration to the former state is possible.

With this explanation we have set forth the principles of the theory of suppuration. But it seems to me advisable to discuss the subject still further. In this further discussion, points of view will present themselves which will be of interest to the clinical teacher, while a clearer insight into the life of the organs may thereby be obtained by the earnest physician.

The Paths for Nutrition and the Spaces for the Collection of Œdema.

At first I shall speak once more of the paths for nutrition in the tissue. According to Virchow's doctrine, the cells anastomosed with one another and through these anastomosing cells the nutritive fluid was supposed to flow. But at that time cells were considered to be hollow spaces filled with fluid, as they are to be seen in dried bone. These hollow spaces were branched and communicated with one another, and it was accordingly believed that these cells communicated, and that they were the paths for the nutritive current. When, at a later period, Recklinghausen had recognized light branched spaces in the cornea (and in other similar tissues) by means of staining with silver, he said that these were the nutritive channels. Thus his hypothesis was a development, as it were, of Virchow's doctrine. According to the latter, the nutritive fluids passed through the hollow cells; but according to Recklinghausen's view only through spaces in which cells lay, and in which they could migrate. When I began to take ground against the hypothesis of nutritive canals (in Recklinghausen's acceptation), I thought, as I have remarked already (page 30), that the nutritive canals or spaces really pre-existed, but that they were filled up. The nutritive fluids, I thought, streamed through the cells, and I had thus really taken up the doctrine of Virchow again, with the difference only that I did not say that the nutritive fluids flowed through hollow cells, but through the protoplasmic bodies themselves. It was occurrences in the protoplasm itself which promoted the current.

In view of this hypothesis, the supposition of spaces in the borders between cells and basis-substance, became superfluous. And yet a number of arguments induced me not to discard entirely Recklinghausen's hypothesis. In

the first place, we could inject the lifeless cornea with the aid of a hypodermic syringe, when the injected mass became disseminated through the tissue. In the second place, we were wont to see real spaces, with shrivelled cells lying in them, in sections of hardened (contracted) corneæ. Thirdly, there seemed to be no doubt that amœboid cells could wander through the cornea. Finally, the assumption of the existence of spaces in the tissue seemed indispensable on account of the occurrence of œdema. Where could the fluid of œdema collect, if there were no spaces? I therefore said that the cells must lie in the spaces as the finger does in a tight-fitting glove. In these spaces the fluid of œdema could collect and compress the cells. But, after experience had taught me that cell and basis-substance could displace their respective borders, I came into conflict with this hypothesis. If a garden bordered on a street; if various reasons made me believe that there must be a ditch between the garden and the street; if, finally, I learned that the owner frequently displaced the garden-fence—now moving it out towards the street in order to narrow the latter, now moving it back again in order to widen the street—if I learned this, I should be compelled to say "I do not understand how there can be a ditch there. This shoving to and fro of the garden-fence, this narrowing and widening of the street is incompatible with the assumption of a ditch." It is just so with the assumption that the cells lie in a hollow, and that there is a space, no matter how small, between the cell and basis-substance.

Further researches, as well as more careful reflection, have also taught me that the grounds which have led to the assumption of a system of canals in the cornea, are altogether deceptive. We are taught in general that the tissue can become œdematous; but physicians know that not all tissues are thus affected. The conjunctiva can become highly œdematous. As far as I know, an œdema of the cornea never occurs. I have likewise never seen an œdema of the substance of cartilage. Marked œdema only arises in those tissues in which, while fresh, we can recognize bundles and meshes of tissue under the microscope, as in the subcutaneous and submucous tissues. Pronounced meshes are also found in the so-called interstitial tissue, between the bundles of muscular fibres,[1] and between the tendinous bundles. Here, accordingly, the result of microscopical examination is in accord with clinical experience, in accord moreover with the fundamental idea "œdema," since "œdema" means a condition such as is caused by the presence of fluid in the spaces of the tissue; of fluid that can be removed mechanically by pressure. Such an œdema does not occur in the cornea, which agrees too with the microscopic picture. For the most powerful microscopes which I now have at command do not enable one to recognize in the fresh cornea even a trace of fissure or cracks. But if the (excised) cornea lies for any length of time on the slide, then, it is true, fissures are formed which are readily recognized, and it is therefore comprehensible that we can see spaces in the shrivelled cornea, that we can forcibly inject the lifeless cornea, and finally, that this can be penetrated by wandering cells.

The Apparent Migration of Cells in the midst of Tissue, and the Vital Processes in the Basis-Substance.

In the normal cornea of the dog and in that of the cat, I have never met with an isolated cell, that is, a cell isolated from the net of cells, in spots

[1] Do not confound bundles of muscular fibres with primitive fibrillæ. Subsequent explanations will clear up this matter.

where the so-called fixed cornea-cells were still preserved, and have never even seen an approach to forms which I might call wandering cells. In the parenchyma of the cornea which is still provided with branched cells, I have until now seen wandering cells only in the case of the frog, and even here I was deceived, as new researches have taught me.

The migration of cells in the living cornea was discovered by Recklinghausen. Now, if I say that this discovery was based on an illusion, the reproach is applicable not alone to the discoverer, but to myself as well, and to all those who have admitted the discovery. Recklinghausen's observation was really one of great excellence, and everybody can convince himself that the forms which were called wandering cells, actually change their position. The essence of this change, however, is not founded on a migration of cells. If somebody should show me a mass of white, hardened wax, which he had poured into a metallic vessel, and should secretly move a flame slowly along under the vessel, I might perhaps see a spot wandering along the surface of the wax, a spot which could be recognized to be melted wax. I could also look towards the bottom, and matters might appear as though a lump of melted wax were wandering through the rigid mass. But, in reality, the wax would not move, it would be only the change (by melting) which would do so. In such a case closer inspection would show me that, on one side, the fluid lump gradually hardened and assumed the character of the remaining wax, whilst, on the other side, it gradually increased in extent by the melting of a new mass of wax. The situation is similar in the inflamed cornea of a frog. On one side, the end of a cell assumes the character of the basis-substance; on the other side, a portion of the basis-substance which borders on the cell assumes the character of the cell. The final result of this change is a change in form and position of the entire cell.[1] I must remark here that the observations on which I base the foregoing statement were made on the inflamed corneæ of frogs, with the slide heated up to about 38° C. [100°.4 F.].[2] My preparations are made as follows: I wound the cornea one or two days before the examination, according to the season of the year. About an hour before the examination I kill another animal, and collect its blood in a small saucer. In the course of an hour the blood is firmly coagulated, and clear serum is collected on the surface of the clot. I draw this serum off with the aid of a capillary glass tube, and put enough on the slide to prepare the excised cornea in it. During the course of the examination I add a fresh drop of serum from time to time.

The observation that migratory cells become altered, and assume the appearance of basis-substance, is really not new. It was known long ago that in the building up of the animal organism cells became metamorphosed into basis-substance; but it was believed that this metamorphosis signified the final destruction of the cell; there was likewise ground for the assumption that this metamorphosis only proceeded slowly. For it takes weeks, months, and at times years, according to the growth of the animal, until the metamorphosis is effected. On the other hand, a rapid change was not altogether unknown. If I am not mistaken, Recklinghausen has already reported that the migratory cells occasionally disappear from view. I spoke of it myself in the year 1869.[3] At that time I had already learned, from long-continued

[1] These observations are difficult, and liable to excite opposition. Yet I cannot enter into a detailed description and proof in this place. I have done so in an article which will be published with the title of "Zellen und Grundsubstanzen" (Cells and Basis-substance). Moreover, I shall again return to the subject in this section (page 36), and shall adduce other observations which will elucidate from another point of view the assertions made in the text.

[2] My heatable slide (see Stricker's Manual, American edition, p. 57) did me excellent service here.

[3] Studien aus d. Inst. fur exp. Path.

examinations, that the tips of cells or entire cells became altered so as to be indistinguishable from the basis-substance. But I was so prejudiced by the tradition that cells and basis-substance differed from each other, that the thought of a rapid metamorphosis never struck me. Since a cell frequently became visible in the place where another had disappeared, I naturally presumed that it was the same one which had previously vanished. As soon, indeed, as a study of the appearances of inflammation had taught me that the cells and their processes extended their limits, and that, too, at the expense of the neighboring basis-substance, I began to change my opinion with regard to the nature of the latter.

But with difficulty only could I conclude to overturn the traditional ideas on the nature and the structure of basis-substance. The basis-substance was said to consist of fibrillæ; the fibrillæ were said, furthermore, to be held together by a cement. And was a cell to become all this so suddenly? I shall show hereafter how a study of the various kinds of tissue has urged me more and more to break with these traditional ideas. Here I will mention only one observation, which has finally induced me to cut loose from this view.

In a fresh condition and with good illumination, the basis-substance of the frog's cornea appears quite homogeneous, though it is different in advanced inflammation. In the neighborhood of the focus of suppuration, the basis-substance becomes quite cloudy, even after the lapse of the first days of sickness. If we allow the inflammatory cause to act several days,[1] scarcely a single spot of the basis-substance remains homogeneous. Here and there the basis-substance looks as if torn and destroyed. It gives the impression of being converted into so-called detritus. But whatever place I may bring into view on the heating stage, I see that the picture changes constantly everywhere. The entire mass is alive. There is present an internal movement similar to the one which I have already described as flowing motion. Such observations, as I have remarked, were made on spots which resembled detritus, and in which comparatively few cells were to be recognized. In certain spots again, in such corneæ, the cells are so densely packed that no basis-substance at all can be seen. Here the cells still form a coherent mass. In certain patches the cells are, it is true, numerous, but there is always basis-substance to be seen which is not yet split up.

Now, again, we have basis-substance which is cloudy, turbid; we can distinguish lighter and darker spots. If we weaken the illumination somewhat (by turning the mirror), the difference between the light and dark portions becomes very plain. Now these clouds are likewise in constant motion; the relations of light and darkness are continually changing. At this aspect I was at once compelled to think of possible illusion. There might be migrating cells lying over and under the cloudy turbidity. The turbidity might be due to an obscuration by migrating cells, which might cause its constant change. But this interpretation proved to be wrong. I saw such cloudy appearances in places where there were cells neither above nor below them. In addition, the cloudy turbidity extended continuously through a considerable portion of the basis-substance. Accordingly, I was compelled to refer the perceptible changes to the basis-substance itself. And in fact a closer observation revealed that the cloudy turbidity passed directly into the amœboid cells.

In view of these observations I was at last compelled to cease doubting. During the process of inflammation, I was now forced to say, not only the presumably[2] fixed cells become movable, but also the basis-substance. It thaws, as it were, from a condition of rigidity. Now I comprehend why the tissue in its entirety suppurates; I comprehend what is meant by the inflammatory resolution of tissue. I comprehend the swelling up of the network

[1] In the case of well-developed frogs, during the first days of October, seventy-two hours sufficed.

[2] I say presumably. In a subsequent section (page 52) I shall show that this assertion also is not quite true.

of cells at the expense of the basis-substance. The cells do not consume the basis-substance, but the basis-substance is converted into cell-body; is transformed again into protoplasm.

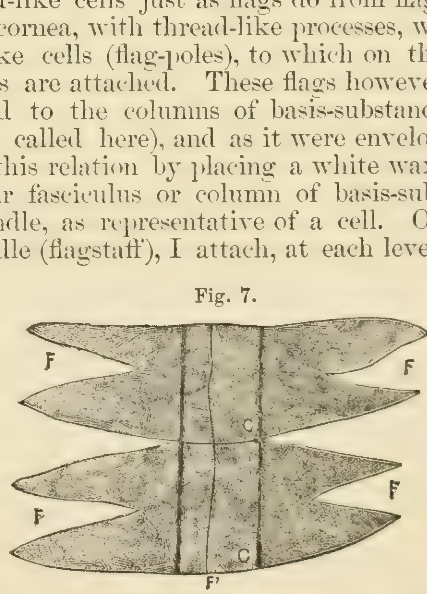
By this time I was finally compelled to drop the assumption of fissures between the cells and basis-substance of the cornea. I was forced to assume that the parenchyma of the cornea was a coherent, living mass, which was traversed by neither crevices nor fissures. In the living cornea no cells migrate; the migration is only apparent. The inflamed cornea of the frog is capable of assuming, at any part, the appearance and peculiarities of the amœboid cell. Such a metamorphosed spot, however, is not yet a migrating cell. It does not become a migrating cell before it separates from its matrix, and such a separation takes place in mass, only in actual suppuration. But this does not exclude the possibility of certain pieces being separated under other favorable conditions, and of their appearing as migrating cells on the surface of the cornea or in some pathological cavity.

I shall return to these new observations on the phenomena observed in the basis-substance, on a subsequent page (p. 52). For the present, what I have said will suffice to make the subject of suppuration of the cornea fully comprehensible.

Suppurative Inflammation in Tendon, Cutis, Bone, Cartilage, and other Connective Substances.

In the *tendon*, the cells have other forms, and a different arrangement from that which exists in the cornea. In the latter, the cells are flat and their broad sides lie parallel to the surface. Hence we see them most advantageously in entire corneæ, or in lamellæ of entire corneæ, if spread out on the slide; for then the cells present their broad surfaces to the observer. But in tendinous tissue, the cells are composed of little rods, which run parallel with the fasciculi of the tendon, and with its long axis. The processes of these cells are ribbon-like; they pass out from the rod-like cells just as flags do from flag-poles. In place of the flat cells of the cornea, with thread-like processes, we have, accordingly, in the tendon, rod-like cells (flag-poles), to which on the same level numerous (three or four) flags are attached. These flags however do not wave free, but become attached to the columns of basis-substance ("fibrillar fasciculi," these columns are called here), and as it were envelop them. In my lectures, I demonstrate this relation by placing a white wax-candle, as representative of the fibrillar fasciculus or column of basis-substance, side by side with a red wax-candle, as representative of a cell. On the free vertical border of the red candle (flagstaff), I attach, at each level, several flags cut out of red paper (Fig. 7), and wrap them about the white candle so as to inclose it as if in a sheath.

Fig. 7.



C, cells. F, flags. F' is called Boll's Streifen, and is nothing else than a longitudinal section of a flag.

In cross-sections, these rod-like cells with pendant processes resemble flat cells with thread-like processes; in short, resemble cornea corpsucles. In the cross-section of a tendon stained with gold, we therefore see a picture analogous to that of the lamellæ of the cornea. In cross-sections of young tendon, the cells are large, and the basis-substance (in this instance the trans-

verse sections of fibrillar fasciculi), on the contrary, sparse. The older the tendon becomes, the smaller are the cells and the thinner their processes, the more extensive on the other hand the basis-substance, *i. e.* the fibrillar fasciculi. These cells and their processes are converted into elastic tissue, as has been shown by Spina. The older the tendon becomes, the more do the cells assume the character of elastic tissue. Hence the great power of resistance in the tendons of old persons and old animals.

The structure of the *cutis* is similar to that of the tendon.[1] Only the bundles of fibrillæ, or, in other words, the columns of basis-substance, do not run parallel with one another as in the tendon, but are interwoven.

Waldeyer was the first to show[2] that the basis-substance in *bone* was formed from cells (called osteoblasts). It has furthermore been shown by Steudener[3] and I. Wolff,[4] that, with the increased age of bone, the cells (bone-corpuscles) become smaller, and the basis-substance between them greater. In addition, Heitzmann was the first to prove fully that the bone-cells had processes which traversed the basis-substance, sent out numerous branches there, and anastomosed with the processes of neighboring cells. The cavities in which the bone-cells lie, as well as the anastomosing network of finest canalculi in which the cell-processes lie, were already known; and it was especially on a knowledge of these facts, as has been previously remarked (page 33 *et seq.*), that Virchow based his theory of nutrition of the tissues. Inasmuch as, adhering to Schwann's views, cells were regarded as vesicles, the small cavities in bone could also be considered as cells. Accordingly we were supposed to know of anastomoses of cells in bone, and herewith to have a substratum for the nutrient current.

But inasmuch as the ideas of histologists on the nature of the cell changed in 1861—inasmuch as since that time we have not ventured to recognize the presence of a cell except upon seeing a protoplasmic body with a nucleus—it has become clear that the cavities in the bone and the canaliculi are the *residences* of the cells, and not the cells themselves. In fact, the cells in bone have only been described at a later period by Krause,[5] and the protoplasmic processes by Heitzmann, as already mentioned. Thus we see a complete analogy between bone and the cornea stained with gold. Here, as well as there, the cells and their processes form a network the meshes of which are filled up with basis-substance; here, as well as there, the basis-substance is produced from the peripheral zones of the bodies of the cells. But bone is distinguished from the other analogous tissues in that lime-salts are deposited in the basis-substance.

More difficult than in the case of bone has been the inquiry into the relation of things in *cartilage*. And yet cartilage is the very tissue which has the greatest interest for us. This interest is in the first place historical, because the earliest observations on inflammatory metamorphoses of tissues were made on cartilage by Goodsir and Redfern. Virchow's theory, that disturbance of the nutrition and function of the cells was the main criterion of inflammation, likewise found considerable support from an observation of cartilage. This tissue interests us, furthermore, because in certain portions, at least, it lacks bloodvessels and nerves. How are the cartilage-cells nourished? How, moreover, is the inflammatory process propagated in cartilage if vessels and nerves are wanting—if the cells besides (each completely isolated) are deposited in firm capsules of basis-substance? Virchow

[1] This has been proved under my supervision by Dr. Ravogli of Rome. See Mediz. Jahrbücher, 1879.

[2] Archiv f. mikr. Anatomie, Bd. I.

[3] Beiträge zur Lehre von der Knochenbildung. Halle, 1875.

[4] Unters. über d. Entw. d. Knochengewebes. Leipzig, 1875.

[5] Anatomie, 2 Aufl. I.

said that the process was propagated from cell to cell. I opposed this view in 1869. The union of the cells amongst themselves I was not yet familiar with at that time, and I could not therefore conceive how the process proceeded from cell to cell.

An insight into the method of nutrition of cartilage was nevertheless granted to me even then. One of my pupils[1] had found that by staining hyaline cartilage with osmic acid he could make canals appear, by means of which the spaces in which the cells lay communicated with one another. Another of my pupils[2] had found that pigment-granules could penetrate the basis-substance of living cartilage. In order to see this, he pointed out, you need only inject the coloring matter into the blood, and then apply an inflammatory stimulus to the cartilage. I availed myself of these discoveries to show that there must needs be a nutritive current in cartilage. In consequence of the stimulus of inflammation, I said, this nutritive current becomes increased. The current must come from the blood. The nutritive current carries pigment-granules along with it. The pigment-granules penetrate the cartilage, and remain lying there; they serve as signs of the current which has passed, just as the stones which are swept along by the torrent and carried off, remain lying somewhere, and serve as signs of the flood which has passed away.

Closely connected with this view of the case, and based on the researches of one of my pupils,[3] was the further assertion that the cartilage-cells likewise underwent inflammatory changes, as stated by Goodsir and Redfern, and as maintained, too, by Virchow and his followers. But my position was hostile to the theory of emigration, and hence the supporters of that doctrine denied the capability of cartilage to participate in inflammation. In like manner, my assertion of the penetration of coloring matter into cartilage was disputed. More recently, however, the penetration of coloring matter into cartilage has repeatedly been seen, and is now quite generally admitted. But Spina[4] has shown even more, namely, that the pigment-granules advance through the processes of the cartilage-cells. The fact that there was cartilage the cells of which were united by processes, was known long ago. But that such was the structure of hyaline cartilage, that the apparently structureless, intermediate substance between the cartilage-cells was traversed by a system of the finest processes, was not known. Heitzmann[5] was the first to report the existence of such ramifications in the basis-substance of hyaline cartilage. He asserted, as early as 1872, that he could see these processes in the fresh condition. In addition, he has made a very fine network appear in the immediate neighborhood of the cells by staining with gold.

But I was not inclined to regard these specimens as conclusive. Meanwhile Spina has advanced new proofs of the existence of such processes; they become visible when a thin section of hyaline cartilage is treated with alcohol. Spina[6] has shown, furthermore, how the cells of cartilage become converted into basis-substance. I shall not enter further into a discussion of this matter, but shall only remark that we have become familiar with a condition of things analogous to that in bone. On the other hand, Kassowitz,[7] after examining cartilage in various pathological conditions, has made the assertion that new cells develop in the basis-substance of cartilage, and that it is itself living matter. Accordingly we now see an analogy between cornea, tendon, cutis, cartilage, and bone.

[1] Bubnoff, Wiener Sitzungsberichte, 1868.
[2] Reitz, Wiener Sitzungsberichte, Bd. 55.
[3] Hutob, Wiener med. Jahrbücher, 1871.
[4] Wiener acad. Sitzungsber. 1879.
[5] Studien am Knorpel und Knochen. Wiener mediz. Jahrb. 1872.
[6] Wiener acad. Sitzungsber. 1879.
[7] Wiener mediz. Jahrbucher, 1879–1880.

True, there are differences between these kinds of tissue. The basis-substances of cornea and cartilage appear homogeneous throughout under the microscope, with this difference, that we can see the cells of normal cartilage in a quite fresh condition, whilst we cannot see those of the cornea until after the application of reagents. In these two kinds of tissue there are no bloodvessels, no interstices with nutrient fluid; they cannot become œdematous. Tendon and cutis are not as homogeneous as cornea and cartilage. In tendon a loose interstitial tissue, in which the bloodvessels run, extends along the more or less dense bundles of tissue; this interstitial tissue can become œdematous. Accordingly only these more or less dense bundles of tissue furnish us with an analogy to the cornea as regards homogeneousness. We have a similar condition in the cutis. But here, as already remarked, the bundles of tissue do not run parallel with each other, as in tendon, but are interwoven, whereby the transverse section in the cutis acquires a very complicated appearance.

Bone is likewise traversed by vessels, and encircling these we have, now abundantly, now more sparsely, a tissue (medullary tissue), which differs from the real compact substance of the bone. With respect to homogeneousness, only the compact substance of the bone is analogous to cartilage.[1] In fact it has now been indisputably proved[2] that compact cartilage customarily passes directly over into compact bone. If cartilage is transformed into bone, canals must be formed in the cartilage, and in these canals bloodvessels must be produced. The formation of canals in cartilage results from a so-called melting or liquefaction (Einschmelzung) of the substance of the cartilage. This liquefaction may be regarded as the physiological type of suppuration. It is exactly the same process as that which, in pathological conditions, we designate as the formation of an abscess. The basis-substance disappears, the cells enlarge and divide. In pathological conditions, we call the cavity which is formed an abscess-cavity, and the products of division, pus-cells. In normal liquefaction (Einschmelzung) the products of division are called medullary cells, and the cavities, medullary spaces. Similar conditions, moreover, prevail in developed bone. The compact substance may liquefy (einschmelzen) in the course of normal development as well as in pathological conditions. In the former instance we speak of medullary spaces and medullary cells; in the latter instance of abscess-cavities and pus-cells.

By the formation of medullary spaces, or of abscess-cavities, cartilage as well as bone becomes porous or spongy. The spongy bone can undergo complete suppuration if the liquefaction makes headway, if the spaces enlarge. On account of the physiological peculiarity of their basis-substance, bone and cartilage form a tissue *sui generis*. Their relationship with the cornea, tendon, and cutis, has until now only been demonstrated with regard to the relation of cell to basis-substance.

In the cutis, as I have said, the bundles of tissue do not run parallel as in the tendon, but are interwoven. In the cutis, however, the network forms compact masses, which do not offer space for the collection of œdema, as far as microscopical examination enables us to judge of the same.[3] Now, there is a series of tissues which consist of bundles analogous to those in the cutis, but in which the interlacement is so loose that fluid can very easily permeate them. To this class subcutaneous and submucous tissues belong. The loosest

[1] I do not refer here at all to the complicated relations in bone, since I cannot enter into a sufficiently detailed account, and I do not know, moreover, how much of the known structure is to be seen in the living subject.

[2] Lieberkühn, Stretzoff, Kassowitz.

[3] Within the cutis itself, however, such collections are probably possible around the vessels.

arrangement of this kind is represented by the subarachnoid tissue. This consists only of single bundles which float in the space filled with fluid.

All of these tissues provided with interstitial meshes, were still called *cellular tissue* during the first ten or twenty years of our century. "Cellular" does not signify that cells are present, in the acceptation of the term as introduced into modern histology by Schwann, but that cell-like, honeycomb-like spaces are present. Joh. Müller has introduced the expression "*connective tissue*," for this tissue. If we neglect the varying width of the meshes, and even the very existence of the meshes, we in fact see a columnar (strangförmige) formation prevailing in tendon, the tendinous membranes, the cutis, the mucous membranes, and subcutaneous and submucous tissues; in the mesentery and in other serous membranes. This columnar formation is peculiar, therefore, to connective tissue, even where it does not produce a *cellular* tissue. In place of *columnar formation*, I shall henceforth employ the more usual term of *connective-tissue bundle.* Accordingly, connective tissue consists of bundles that are united in various ways. But every bundle consists of cells and basis-substance. Every bundle, whether large or small, therefore, forms a compact mass similar to cornea and cartilage. Every such bundle can suppurate, and that, too, in the same manner as described for the cornea.

Theory of Fibrillæ and of Connective Substance.

Every bundle such as can be made to appear in tendon, cutis, subcutaneous tissue, subarachnoid tissue, and others, may also be designated *fibrillar bundle.* Now the question of the occurrence and genesis of the fibrillæ, constitutes one of the most important chapters of normal and pathological histology. I might almost say it constitutes one of the most important chapters of all pathology. For that frightful host of diseases which are designated as cicatrizations, contractions, scleroses, and (in order to make special mention of only a single series), those severe forms of disease of the central nervous system known as tabes dorsalis, lateral sclerosis, and multiple sclerosis, which, though probably only chronic inflammations yet lead to the destruction of life in spite of all remedies, all consist essentially in the formation of such fibrillæ, or, still better, of a transformation of the nerve tissue into fibrillar tissue.

Histologists had recognized the fibrillæ by the examination of tissues that were dried or altered (contracted) by reagents. If we soften in water a dried cornea or a dried tendon, and tease it, we will see under the microscope very fine fibrillæ, which are arranged at times in large bundles, at others in small ones, or which traverse the field of view singly and in an irregular manner; in short we receive the impression that the entire tissue consists of such fibrillæ, but that they have been thrown into confusion by the teasing. On the ground of these observations, it was said: Cornea, tendon, and cutis consist of fibrillar tissue. On similar grounds we can go further, and say in general: The connective tissue cords consist of fibrillæ, they are bundles of fibrillæ. More recently the basis-substance of macerated cartilage and bone has also been recognized to be fibrillar. And thus we see another analogy between connective tissue, on the one hand, and bone, cartilage, and cornea, on the other. They all consist of cells and basis-substance; in the dried or macerated state they all disclose a fibrillar structure.

In the year 1845, Reichert classified all these tissues, and a series of others which I will mention hereafter, under the common name of *connective substance.* Reichert in effect denied the existence of fibrillæ in a series of tissues. It was not the fibrillæ, but a peculiar substance, which was characteristic of all these tissues. Thus the term *connective substance* indicates, as it were, a

histological theory. The entire armament of the older microscopic methods was brought to bear on this assertion of Reichert. In the first place it was Alex. Rollett, who, under Brücke's direction, demonstrated the existence of these fibrillæ in spite of Reichert's assertion. The fibrillæ, he said, are united by an albuminoid cement. If we preserve the cutis in lime-water, or in baryta-water, the cement is dissolved, and the fibrillæ fall apart. These results agreed with the tendencies of the microscopists of that time, and a large majority of histologists take this standpoint even at the present day. The doctrine of the fibrillar structure of connective tissue appeared, and still appears, to stand on a solid foundation. The disclosure of fibrillæ in bone by Ebner,[1] followed entirely in the spirit of the method by which Rollet had demonstrated the existence of fibrillæ in the cornea. It was the old method of examining macerated tissues. We are very much indebted to these methods. By their aid histology acquired its first solid foundations. The examination of contracted and macerated specimens is indispensable even to-day, and will remain so, perhaps, for all time. But the results must be checked by the examination of living tissues; by the examination of tissues at various ages of their growth; and finally by the examination of the tissues in pathological conditions. Neither the cornea, nor the tendon, nor the cartilage, permits of the recognition of fibrillæ in the fresh state.[2] The basis-substance appears homogeneous in all.

Now the objection may be raised that this proves nothing. The basis-substances appear homogeneous, because the fibrillæ are united by a cement; because fibrillæ and cement possess the same optical properties. If I deny the existence of fibrillæ on account of the homogeneous appearance of the basis-substance, I must likewise deny the existence of the cornea-corpuscles, it may be said. For the fresh cornea shows no structure at all; it is of a glassy brightness. Must we not admit nevertheless that the network of cells does exist, but that we do not see it because it possesses the same optical properties as the basis-substance? Now this is a very weighty objection, but it is open to discussion, and in order to elucidate this question I shall next introduce a few remarks on the cell-nucleus.

On the Cell-Nucleus.

If we examine an amœboid white blood-corpuscle of the frog, we will at times see nuclei, and at times not. A more accurate examination teaches us[3] that the nuclei come and go; that new nuclei also are formed, now in this, now in that part of the cell. It happens furthermore that on one side a nucleus gradually acquires the character of the cell-body, while on the other side a new addition is made to the nucleus from out of the cell-body. But as soon as we add acetic acid, nuclei immediately arise in definite shapes, in shapes that were previously not present. This configuration is now a lasting one, since cell and nucleus have become lifeless. The nuclei as they appear in reaction with acetic acid have been known long since. If anybody had asserted twenty years ago that such nuclei did not exist in the living white blood-corpuscles, the assertion would certainly have been regarded as entirely unjustifiable. Now matters are different. The assumption of the appearance and disappearance of nuclei in certain varieties of cells, is almost

[1] The fibrillæ of bone were known before this; Waldeyer had described them in Max Schultze's Archiv, Bd. i.

[2] Examined in aqueous humor immediately after excision.

[3] First observed by Arndt, and then by myself (Wiener mediz. Jahrbücher, 1878). But the reader must refer to my article, since there are several varieties of colorless blood-corpuscles.

universally admitted. The zoologists even say that my observation is not at all a new one; that they were familiar with this phenomenon long ago, in the case of the lowest animal forms. Thus, in spite of the majority of cells (for example, young epithelial cells) having recognizable nuclei in the living specimen; in spite of the nucleus being still regarded as an attribute of the cell, it is nevertheless admitted that there are cells in which the nucleus is not a constant factor—in which, at times, there is no nucleus at all present. Furthermore, a majority surely of all pathologists admit that, during the process of inflammation, nuclei appear in such large numbers as to exclude every doubt of their new formation.

Now one might say that this is just the condition of things in the case of the network of cells in the cornea. It is true that cartilage and some other tissues enable us to recognize cells in the living specimen; it is true, likewise, that we can regularly make cells appear in the cornea by the use of reagents; it is true that we can also see them in the inflamed cornea in a fresh state. But from the instances already cited, we cannot conclude with certainty that they exist in the normal cornea.

However, I have made new observations on this matter, and when, on a subsequent page, these observations are mentioned, I shall revert to the matter in hand. But before doing so I must consider a series of other tissues.

Comparison between the supposed Fibrillar Substances and the other Connective Substances.

A series of tissues, the structure of which is essentially different from that of those already mentioned, is likewise included in the list of connective substances; I mean the so-called framework of the brain and spinal cord (neuroglia, Virchow), and the so-called adenoid tissue in the lymphatic glands. This tissue consists of cells and their processes, the latter being branched and forming an extensive network. The network is really the characteristic part of the tissue. The cells (points of junction of the network) are entirely absent in certain parts, as, for example, in the sinus of lymphatic glands. Since fibrillæ were regarded as characteristic of the connective substance, one was inclined to suppose that this meshwork took the place of the fibrillæ. But the meshwork of the adenoid substance, as well as that of the neuroglia, is on the other hand analogous to the network of cells in the cornea, in bone, in tendon, etc.; while the fibrillæ into which the latter tissues appear split (after maceration) traverse the basis-substance like the threads of woven cloth. Hence the network of the adenoid substances and of the central nervous system cannot be regarded as analogous to the fibrillæ of the connective substances. The analogy between these tissues must be sought for in other points.

In the lymphatic glands, the meshes of the network are filled with a fluid in which the lymph-corpuscles float, whence the whole tissue is so soft and spongy. In the gray matter of the brain and spinal cord, the network is filled with a mass which we do not thoroughly understand; with a mass which gives to the gray matter its peculiar consistence. In the white matter of the brain and spinal cord, the meshes of the network are adapted to the nerve-fibres; in other words the nerve-fibres are stuck into a net of connective substance. It is probable, furthermore, that in the cornea, in bone, in cartilage, in tendon, etc., the meshes are filled with something that gives to each of these tissues a characteristic physical state. In bone, for example, it is the lime-salts mixed perhaps with other substances. We see accordingly that, in a lifeless condition, each of these tissues belonging to the connective substances

shows cells under the microscope, besides a network of processes and an intercellular substance. If the cornea, or the cord of the tendon, has fallen apart into fibrillæ, the cleavage extends through the entire basis-substance, as was first recognized by Heitzmann; it implicates the network as well as the intercellular substance. Only the cell-bodies themselves (the points of junction of the network) withstand the cleavage here and there. Hence also, histologists of former times taught that connective tissue consisted of bundles of fibrils and of connective-tissue corpuscles.

The Transversely Striped Muscular Fibres; Continuation of the Discussion on the Nature of the Fibrillæ.

The property of being resolved into fibrillæ belongs not only to the connective substances, but also to other varieties of tissue. It has been made known (by Brücke if I mistake not) that transversely striped muscles which have been preserved in alcohol, are very easily separated into very fine fibrillæ. This method of preparation presents us with really splendid pictures of bundles of fibrillæ. Each fibril shows the rudiments of the transverse striation, and accordingly looks like a string of beads. On this account, too, we call the transversely striped muscular fibres, *bundles of primitive fibrils.* All the strings of beads together make up the bundle, the muscular fibre, this lying in a closed sac (the *sarcolemma*) which is everywhere closely adherent. Formerly, every such fibril was thought to consist of a series of little rods (*sarcous elements*), that were united by a kind of cement, an intermediate substance. As long as the fibrils cohere, it was said, they present the appearance of transverse striation, because a number of sarcous elements with intermediate substance are arranged in juxtaposition, and run in a transverse direction. But it was supposed that the muscular fibre could be divided into disks, as well as into fibrils. Muscles of the *hydrophilus*, preserved in dilute muriatic acid, present such an appearance.[1] Every such transverse disk, consisting only of sarcous elements, was called a Bowman's disk. Following Brücke and Rollett, Bowman's disks also received the name of *chief substance* (Hauptsubstanz) and the cement between them that of *intermediate substance.*

During the last fifteen years, however, the theory of the structure of muscles has materially changed. During this period, so many new and contradictory views on this subject have been published, that I am scarcely able to form a clear idea of the state of literature on the question. Therefore I cannot give a general survey of it, and I have no inclination to do so. I believe that the histologists who are at the present day quarrelling about the presumably very complicated structure of muscles, are on a wrong path. I have conclusive proof that muscle (as far as its perceptible, microscopic structure is concerned) is very simply formed. But I should like to support the description I intend to give by first drawing the following picture. In the transversely striped muscle, the appearance of things is at times somewhat the same as in a dance. The couples change, and the grouping varies. Whoever does not observe the changes, will, it is true, always see dancing couples. Nevertheless they are not always the same couples. And it may happen that at one time only single pairs are dancing; at another time two pairs are grouped together; then again several pairs. The dancers may resolve themselves into rows walking in single file (fibrillæ), or may form a broad front and march in columns. Finally, they may break up the dance and move about without regular order, or may remain quiet after breaking up.

[1] But as a rule several disks adhere together in the specimens.

If we look at the freshly excised (living) muscle from the extremity of a *Hydrophilus piceus*, we can observe transformations which correspond to the picture just drawn. The muscle of the aforesaid insect still makes very active movements under the covering glass of a slide. The mass of the muscle undulates to and fro, as it were, and the details therefore cannot be readily perceived. When it has become somewhat quieter, we can see so-called contractile waves proceed along single fibres; a knot, a protuberance, apparently passes along the muscular fibre. If the muscular fibres have remained any length of time on the slide, very peculiar phenomena make their appearance, which are probably pathological, because they are the forerunners of death. Some of the muscular fibres suddenly become converted into bundles of fibrillæ; suddenly the fibrillar structure disappears, and the broad ribbon-like character returns in its stead. Then, again, we see variations in the breadth of the ribbons, and in their distances from each other. In addition, the internal structure of the broad bands changes. At times, such a band is bright in the middle and dark at the lateral zones; at times the condition is reversed. The dark zones appear granular and irregularly bordered at one time, and at another homogeneous. Suddenly the transverse striation disappears in a fibre, and it assumes a fibrillar structure. Then the fibrillæ are suddenly lost to sight, and the muscular fibre looks like a homogeneous mass provided with granules. A renewed undulation and we have again the ribbon-like appearance.

As long ago as the year 1870,[1] I gave a similar description in my Manual of Histology. The more modern histological school, however, has scarcely taken any notice of this description. A number of distinguished histologists, then as well as since, have described certain of the variable phenomena as the structure of the muscle, and in this state of affairs it is comprehensible that very different views should prevail. One of my pupils (Heppner) has accounted for some of the variable phenomena on the ground of optical illusions. But I must now acknowledge that I myself was deceived in this respect. There are no optical illusions in question here. What Hensen, Krause, Engelman, Merkl, and other histologists have described in the muscle, is really based on fact, but the fact itself is not constant. The muscles of the trunk of the frog, and also those of mammalia, are not as changeable as the muscles of insects. In the former instance the condition is really one of stability as long as the tissue is normal; but as soon as the muscle of the frog has an inflammatory stimulus applied to it, the stability ceases. True, no such movements arise as in the Hydrophilus muscle. There is a slow displacement—a displacement such as I have called *internal flowing motion* in the case of the white blood-corpuscle. Moreover, when a muscle is about to suppurate, the internal changes become more striking. The muscle loses its transverse striation, the nuclei increase in number, and finally the transversely striped muscular fibre is converted into a mass of young cells or pus-corpuscles.

Such changes, and others which are analogous, have been repeatedly seen since the time of Bardeleben (1842), in inflammatory and non-inflammatory new formations in muscle. Otto Weber, Waldeyer, Tchanisky, and C. Weil (the two latter under my direction), and many other authors, have given accounts of such processes. More recently, the inflammatory processes have been again very accurately studied by Spina, who has found that not only pus-corpuscles, but also blood-corpuscles, can be developed from the transversely striped muscular fibre.[2]

[1] Stricker's Manual, American edition, pages 1086, 1087.

[2] A similar discovery in the case of carcinomatous degeneration of the muscles of the tongue had previously been made by C. Weil.

These observations, now, force me to hold the following view: The muscular fibre is a contractile mass surrounded by a tube (*sarcolemma*), a contractile mass which, at the time of a normal discharge of function, has the peculiar appearance of transverse striation, or more correctly, of possessing transverse bands. But it is only a certain arrangement of the contractile substance which gives it this appearance; an arrangement consisting, perhaps, only of a varying density[1] of the mass. This arrangement can vary according to the order to which the animal belongs, and according to the function of the muscle. It can lead to all the changing appearances which have been described by histologists. In the fresh (living) specimen, the muscle can resolve itself into fibrillæ, and it is probable that the fibrillæ which are to be seen in specimens preserved in alcohol, made their appearance just previous to death. The best proof of the fibrillar change of the living muscles is offered by pathological processes, especially by inflammation, as has been shown in a most exhaustive way by Friedreich.[2] The fibrillar change in disease can also be regarded as a fibrillar degeneration, as a destruction of the muscle. Besides, we know still another form of destruction of the muscular structure. The muscle may lose its peculiar, transversely-striated appearance, and become a homogeneous, granular mass. Such an appearance of the muscles has induced those pathologists who always examine only lifeless tissues, to believe that the homogeneous appearance is a sign of the death of the fibre. But the muscular fibre can continue to live as a homogeneous mass. Its nuclei can multiply; it can suppurate; it can become converted into blood-corpuscles; it can produce fat-granules. Various circumstances even seem to indicate that it may regain its normal state after a loss of the transverse striation.

After this explanation, I return once more to the question of the nature of the fibrillæ. Is the living muscle fibrillar? Does the muscular fibre consist of a bundle of fibrillæ? We can now scarcely answer this question affirmatively. And yet we must admit that there must be something contained in the muscle to permit of its changing into fibrillæ under the influence of certain stimuli. If we stain the living muscular fibre with chloride of gold, we recognize a fibrillar structure in the specimen; indeed, here the fibrillæ or little bundles of fibrillæ seem united by an intermediate substance of a deep violet color. This arrangement has been the subject of numerous discussions. Gerlach[3] has asserted that these deep violet tracings between the fibrillæ are the continuations of the nerves. But Gerlach's assertion has been denied in various quarters. I must confirm the fact that there is a continuity between the threads of the terminal nervous apparatus (which are likewise stained a deep violet color) and the afore-mentioned violet intermediate substance. But that we have here really to deal with the continuations of the nerve, I do not dare to assert. There is a stage in the course of the inflammatory process in which the entire mass of the muscle has already changed its appearance. The transverse stripes have already disappeared; the approach to suppuration is already declared; nothing more is to be seen of the violet tracings, but the terminal nervous expansion of Kühne[4] is still to be seen distinctly, and almost unchanged. Considering this, I must now admit that in the muscular fibre, alongside of the main mass (the contractile substance), there is distributed still another substance which stains of a deep violet color —a substance which perhaps favors the separation into fibrillæ. The question

[1] The beautiful color phenomena seen with polarized light (Brücke) are well calculated to support this view.

[2] Ueber progressive Muskelatrophie. Berlin, 1873.

[3] Max Schultze's Archiv, Band xiii.

[4] This is the terminal nervous expansion situated between sarcolemma and the contractile substance, and was discovered by Kühne. [Note of the Translator.]

of the nature of this substance is undecided, as is also the question of how this substance is distributed in the living muscular fibre.

As regards the fibrillæ, we have not yet reached a decision. For the present, let us remember that the fibrillæ may appear and disappear again in the living muscle, and, furthermore, that in disease the muscular fibre can be definitively transformed into fibrillar bundles, not, however, losing thereby its functional power. And, relying upon these and other experiences, we will soon obtain a definitive answer.

The Smooth Muscular Fibres and the Central Nervous System. Continuation of the Discussion on the Fibrillæ.

A more searching criticism of the hypothesis of the pre-existence of the fibrillæ, is furnished us by those tissues which normally never appear fibrillar, whether examined in a fresh or in a macerated state, though it is true that they may become fibrillar when subjected to pathological changes. To this class belong:—

(1) *The Smooth Muscular Fibres.*—In the normal state we recognize the smooth muscular fibres as spindle cells with oblong nuclei. In case of suppuration, the smooth muscular fibres may subdivide and form pus-corpuscles. But there is a regular series of chronic processes in which they are changed into fibrillæ. The close relationship between *fibroma* and *myoma* is based on these transitions. In such neoplasms, we find undivided (non-fibrillated) smooth muscular fibres next to bundles of fibrillæ. Hence we may be in doubt as to whether we have to deal with a fibroma or a myoma, according as one or the other tissue is more abundant.

(2) *The White and Gray Matter of the Central Nervous System.*—I have already stated that the medullated fibres of the white matter are stuck into a filamentous network of connective substance. This network is directly continuous with that fine network which constitutes the neuroglia of the gray matter.[1] In the gray matter, however, the network is filled up with a mass which, in the living specimen perhaps, is homogeneous, but which appears finely granulated in hardened preparations. This fine network, *plus* the mass in its meshes, constitutes the basis-substance of the brain and spinal cord. In this basis-substance the ganglion cells and their processes are situated. These processes are of two kinds, as was first shown by Deiters.[2] In the first place, we have axis-cylinder processes, such processes as penetrate the white matter and become the axis-cylinders of the medullated fibres. In the second place, the ganglion-cells send out processes which form connections with the network of the neuroglia. These processes were called by Deiters *protoplasma processes.* Besides the ganglion-cells, we meet with other cells in the gray matter, concerning the nature of which we are not quite clear, and the processes of which are likewise continuous with the network. Many of these cells are called connective-tissue corpuscles.

As I cannot here enter into the discussions on the minute structure of the gray matter,[3] I rest satisfied with this description, and recapitulate as follows: In the gray matter there are ganglion-cells and other cells, the processes of which form a fine network. The network, *plus* the mass in its meshes, constitutes the basis-substance. But there are also processes which originate in the ganglion-cells, pass directly into the white matter, and con-

[1] This network is identical with the substance called "neuroglia" by Virchow. It was first accurately described by Bidder and Kupffer. See the history in my Lectures, p. 561 *et seq.*

[2] Untersuch. über Gehirn und Rückenmark. Braunschweig, 1865.

[3] See my Lectures; Lect. xxxii. p. 561 *et seq.*

stitute the axis-cylinders of the medullated fibres. In addition, the network of neuroglia in the gray matter is continuous with the network of neuroglia in the white matter. In the white matter, however, the network is not filled up with a granular mass, but the meshes of the network adapt themselves to the nerve-fibres. The cells in the neuroglia of the white matter are sparse and very small.

Besides the network of neuroglia, another network is found in the white matter, namely in the medullary layer of the nerves. This network was discovered by Kühne and Ewald.[1] The medullated fibre consists of the axis-cylinder, of the medullary layer, and of a structureless sheath (Schwann's sheath)[2] which limits the medullary layer externally. Now it is the medullary layer which contains the aforementioned net. The meshes of this network are here filled with the peculiar substance that we call *medullary substance.* This is a substance rich in fat, which lends to the entire nerve its opacity. If we wish to see the network, we must extract the fat with alcohol and ether, or with alcohol and turpentine. Having deprived a peripheral nerve (for example, the sciatic nerve of the frog) of its fat, we recognize with a magnifying power of 300 diameters, or better still, with a higher power, that the space between the axis-cylinder and Schwann's sheath is traversed by a knotted network; by a network whose meshes now (after the extraction of the fat) are light and transparent, thus making the trabeculæ of the network very plainly visible. This network is inserted on one side into the axis-cylinder, on the other side into Schwann's sheath. Similar networks, though not as sharply defined, are also contained in the medullary layers of central nerves, and in the white matter of the brain and spinal cord. But not all the nerve-fibres of the white matter are medullated. We have, in this respect, the most varied gradations, from nerves with a very thick medullary layer down to nerves with a very thin one, and even axis-cylinders which do not show the presence of a medullary layer at all. Transverse sections of the spinal cord of man, or of the dog, which have been hardened in a two per cent. solution of chromic acid, and then in alcohol, show these relations very plainly, especially if they have been washed well and stained in carmine. For the network of connective tissue as well as the axis-cylinders are stained red by carmine, whilst the medullary layers remain almost colorless.

If we cause inflammation and suppuration in the spinal cord of a dog, by means of injury, and then prepare it in the manner described, we learn as follows: In the immediate neighborhood of the suppurating spots, the axis-cylinders are thickened. This thickening is very unequal. We find axis-cylinders which are about as thick as a connective-tissue cord of the cutis, and all gradations down to the thinnest axis-cylinders of the normal spinal cord. The markedly thickened axis-cylinders have no longer a medullary layer. The medullary layer is destroyed by the thickening of the axis. Here the relation is exactly the same as it is between cell and basis-substance in the cornea, in cartilage, and in other tissues. The axis-cylinder of the nerve takes the place of the cell; the medullary layer represents the basis-substance. The medullary layer as basis-substance is distinguished from all other basis-substances in that the meshes of the network in the medullary layer are filled with medullary substance, rich in fat; it is distinguished, furthermore, in that the network of the medullary layer is easily demonstrable in fresh nerves; and finally in that this network is as firm and resistant as elastic tissues, as has been shown by Kühne and Ewald. But this network is firm and resistant, only in a normal condition. In the course of the inflammatory process, it

[1] Verhandl. d. naturhist. mediz. Vereins, Heidelberg, 1877.
[2] Equivalent to tubular membrane. [Note of the Translator.]

again becomes similar to the embryonic protoplasm. During this transformation the medullary layer disappears. Axis-cylinders and network now coalesce, and form one mass, which looks in transverse section like a large axis-cylinder. But in longitudinal sections we see that the swellings are very unequal; that marked intumescences alternate with spots of almost normal dimensions. Hence the swollen axis-cylinder is wont to look like a knotted club. In these swellings new nuclei arise (as was first recognized by Dr. Hamilton).[1] Hence a multinucleated protoplasmic mass takes the place of the medullated nerve. These large nucleated masses soon subdivide into smaller cells which resemble pus-corpuscles.

This process, however, does not represent the ordinary form of suppuration of the spinal cord. When the spinal cord suppurates, large numbers of cells containing fat granules are formed. Now with regard to these fat cells in the inflamed spinal cord, a student, Ernst Bäumler, has under my supervision quite recently obtained very remarkable results; results which throw a remarkable light on the theory of suppuration as well as on general histology. The cells with fat granules which occur in the spinal cord are essentially different from such fat cells as the colostrum corpuscles, and the fat cells found in the liver and in other glandular organs. The fat cells of the spinal cord are characterized in the first place by their very great variation in size, and by a peculiar appearance of the fat globules. But this is a minor consideration. Of much greater importance are the things which are to be seen in the interior of these fat cells after the extraction of the fat. Many of these cells still bear distinct traces of their genesis. Their body consists of a network of exactly the same kind as is observed in the still connected portions of the spinal cord in the neighborhood of the suppurative focus. Whilst on one side of the specimen (that is, towards the cavity of the abscess), these peculiar reticulated cells are found isolated, in the immediate neighborhood they are still connected together, though the lines of partition are already indicated; and somewhat further off even these partition lines are wanting, though exactly the same network is present as in the cells. There can no longer be any doubt that the entire mass of white and gray matter has become subdivided, in exactly the same manner as has been demonstrated in the case of the cornea by staining with silver.

In the case of the cornea, however, a flaw, though only a slight one, still remained in the argument. Are the cells in the already completed abscess-cavity (*i. e.*, the cells after the destruction of the tissue) really the same as the cells indicated by brown lines in the silver-stained specimens of tissue not yet broken down by suppuration? This is, in a high degree, probable; but the pus-corpuscles of the cornea contain no direct signs of their genesis. In the other case, however, the subdivisions still bear signs of their origin. In the network there remain probably the débris of the very fatty medullary substance (really intermediate substance). It is presumable, moreover, that the tissue also produces new fat. For the production of fat is one of the specific peculiarities belonging to various tissues, and, among others, to the white nerve matter. However, let the fat come whence it may; the essence of the affair is not changed thereby.

Not rarely we see also a nucleus in the network of some cells, on one of the trabeculæ. We also find cells in which the system of trabeculæ is only partly preserved, the remainder already having formed a homogeneous mass. This phenomenon is entirely comprehensible. I have proved by direct observation[2] that cells which expel their fat-globules afterwards resemble ordinary

[1] Quarterly Journal of Microsc. Science, vol. xv., new series.
[2] Wiener Sitzungsberichte, Bd. 53; 2te Abth.

solid amœboid cells. On the other hand, we know that in every amœboid cell vacuoles can appear and disappear. From researches which have been made under my direction on the genesis of nerve-tissue,[1] we know moreover that embryonal cells, while building up the nerve-tissue, while being transformed into tissue of the central nervous system, produce numerous small vacuoles within their body, and thus are directly converted into a network. Only subsequently is the medullary substance produced within the network. Accordingly, the entire tissue is subdivided during the process of suppuration into components analogous to those from which it was constructed.

Suppuration of the spinal cord is one of the rarest occurrences, unless as the result of injury. The chronic forms of inflammation, however, are less rare. Chronic inflammation of the spinal cord is characterized in most instances by the growth of the network of connective substance. The growth represents itself as an increase in mass of the various trabeculæ of the network, and this increase in mass occurs at the expense of the neighboring tissue, at the expense of the adjoining nerves. In the thickened trabeculæ of the network of connective substance, we also still see vestiges of the axis-cylinders; vestiges of varying distinctness, according to the degree of metamorphosis which they have already undergone. Such a condition is found in tabes dorsalis, in the scleroses of the lateral columns, in ordinary chronic myelitis, in syphilis, in the myelitis of drunkards,[2] and in other chronic forms of disease.

In the severe and progressive forms, however, the change does not cease with this thickening of the connective substance. The thickened network of connective substance, and the inclosed nerve-fibres, break down into fibrillæ, as was first shown under my supervision by Dr. Nath. Weiss, in a case of tabes dorsalis. The destruction takes place principally in a direction parallel to the longitudinal axis of the spinal cord. In such places we find the white matter of the cord replaced by a fibrillated tissue. Here and there the bundles of fibrillæ still have the same arrangement as in the normal tissue. In a transverse section we still recognize the arrangement of axis-cylinders and network; but they already consist of fibrillæ which appear (in transverse section) as small granules, but which can be followed deeper down (in the longitudinal direction) by the aid of the fine adjustment, and are thus recognized as sections of fibres. On one side, these spots border on a tissue with no indication of a fibrillar degeneration, in which we can recognize the swollen network of connective substance and the medullated nerves, and on the other side on a felt of fibrillæ, from which every trace of the former tissue has disappeared. Here we accordingly see again (just as in the case of the muscle) a final result of the chronic process which in its consequences as regards the function of the part, is similar to an acute suppurative inflammation. In the one case, as in the other, the nerve-tissue, as such, is destroyed, and the function of the corresponding nerve territory is lost for ever.

But from a clinical point of view, the two processes vary in the extent of the destruction. An acute process is, as a rule, limited. In this respect let us consider a cutaneous abscess as typical. Such an abscess, in any particular instance, never spreads beyond its original site. The infiltration limits itself, breaks down in the centre, and therewith the height of the process is reached. If no new abscess is formed in the neighborhood, we may look forward with some certainty to the termination of the process. The circumstances are similar in regard to all abscesses, though the importance of the

[1] See my Lectures, page 568.

[2] I obtained a view of the appearances in these forms of disease through the kindness of Dr. Nathan Weiss, who prepared the specimens in my laboratory.

organ, the functional value of the destroyed portion, must be taken into consideration. Not such is the course in those chronic forms of inflammation that lead to fibrillar degeneration. Judging from the view now prevalent with regard to tabes dorsalis, these processes are terminated by death only. Slowly but steadily does the transformation, the metamorphosis of the tissue, proceed, and thus destroy the function of the organ. Hence, in their importance to the organism, these chronic processes are to be compared with malignant new formations. But we must here note the following considerations: As long as the fibrillar degeneration has not taken place, as long as the chronic inflammation has not passed beyond swelling of the network of connective substance, from the histological standpoint[1] a cure is still conceivable. Accordingly, if physicians should ever be enabled to arrest the progress of the disease before the fibrillar degeneration had taken place, a complete cure would still be possible. It also appears certain to me that absolute rest, that the absolute avoidance of functional hyperæmia, is one of the means by which a return to the normal condition in certain well-marked forms of myelitis may be hastened. But where the fibrillar degeneration has taken place (and this holds good for the advanced forms of the disease), a return to the normal state is not to be thought of.[2]

I shall now make use of this explanation for a further discussion of the fibrillar structure of tissues. The assertion that the white matter of the spinal cord was fibrillar, in the same sense as the cornea or the tendon, would surely be rejected by histologists, and justly so. And yet, under certain circumstances, it breaks up into fibrillæ. The objection may be raised that this only holds good in the case of disease. It may be said, indeed, that here a metamorphosis has first taken place; that the entire tissue has first returned to the embryonic condition; that it has virtually become something different from what it was. First it became connective tissue, and then only did it break up into fibrillæ. On the other hand, however, we must consider that the line between pathological and normal processes is drawn arbitrarily, and only with reference to the practical requirements of man. The assertion that the nerve-tissue which has returned to the embryonic condition is now become connective tissue, is also quite arbitrary. True, the axis-cylinders coalesce with the trabeculæ of connective substance. But these trabeculæ likewise have returned to the embryonic condition. Now who will assert that they are still connective tissue? And who can claim that the axis-cylinders have been converted into connective tissue? If we wish to judge objectively, we must accept facts as they appear to us. The axis-cylinders break up into fibrillæ; this is a fact; but what the fibrillæ are we do not know. But this we know—that they are not nerves, and that they no longer perform the function of nerves.

New Observations on the supposed Fixed Cells. Conclusion of the Discussion on the Nature of the Fibrillæ.

I have already mentioned that immediately after excision of the normal cornea we can observe in it no trace of structure, but that we can render the cornea-corpuscles visible by means of various reagents. Now the circumstance that this reaction appeared so regularly—that after staining with gold,

[1] This matter is discussed in my Lectures, and I shall treat of it more in detail in a separate publication.

[2] Perhaps further information in regard to the etiology of these affections will teach us that the steadily progressive processes are dependent upon some constitutional condition, such as the presence of syphilis or other infectious disease. This has already been conjectured.

for instance, the violet-colored branched corpuscles appeared—made us incline to the belief that these corpuscles existed in the living cornea. Moreover, this conclusion seemed to be supported by the fact that the branched corpuscles were wont to appear with the same configuration—though isolated—if the normal fresh cornea lay in aqueous humor several hours after excision; and, finally, by the fact that they were visible in increased numbers immediately after the excision of an *inflamed* cornea. It did, indeed, seem strange to me that in the inflamed cornea they appeared only here and there, and, moreover, that the specimens stained with gold had a different appearance in winter from that which they had in spring and autumn. If, as has been supposed, the branched corpuscles are arranged in the living cornea exactly as they are in the specimens stained with gold, then, judging from the latter specimens, we must admit that they are differently formed in winter and in spring. According to this supposition, therefore, the branched corpuscles are not fixed in the sense that they continue unchanged during their entire existence.

Still another circumstance warns us against drawing unrestricted conclusions as to the state of the living tissue from lifeless specimens stained with gold. If we paint the cornea before excision with a stick of nitrate of silver until it has become cloudy, excise it about thirty minutes later, and then expose it to diffused daylight, we obtain a picture which is essentially different from that obtained by staining with gold. In a specimen thus treated, the processes of the cornea-corpuscles appear branched to such a degree that the basis-substance is traversed by an excessively rich network. With a magnifying power of about 1000 diameters, the basis-substance looks like a loosely woven tissue. Since I had observed similar networks in the gray matter of the brain, and since, moreover, similar networks were known to exist in bone, I expressed the opinion that all organs were built up of such a fine network. The network, added to the mass which filled up its meshes, formed, as I thought, the basis-substance, whilst the cells were nothing else than parts of this network with a different density, and a different mass filling their interior. In the cells, I thought, there is a fluid (*intracellular fluid*), whilst the basis-substance has a mass in its meshes which lends it its characteristic physical stamp, different in bone, different in the cornea, different in cartilage—in short, varying according to the nature of the tissue. But the very marked ramification which we see in corneæ painted with silver, does not appear in specimens stained with gold, though here also the ramification is at times very extensive. At times, I say, but not always. Accordingly, the reagent must have some influence on the conformation of the lifeless and fixed condition; the cornea-corpuscles and their processes must perish in varying shape in consequence of varying influences brought to bear on them.

Besides, after proof had been offered that the cornea-corpuscles became altered in consequence of an inflammatory irritation; that in the cornea of the frog they appeared essentially altered, even a few hours after the application of the irritant; that they lost their processes here and there and were transformed into relatively large multi-nucleated masses; after I had made, moreover, the observations on the cornea of mammalia which led me to adopt the theory of inflammation and suppuration already described—the theory that the cells and their processes swell at the expense of the basis-substance—in view of all these considerations, I had all the more ground to doubt the stability of the supposed fixed cells. And yet not until quite recently have I shaken the axiom that the branched cells in the normal condition are fixed cells.

During the past year, Dr. Hänsell has been engaged under my direction in

studying the keratitis of infection, and in so doing has met with very remarkable experiences in regard to the processes taking place in the cornea of the rabbit. It appeared that, while, on the one hand, the network of cells increased at the expense of the basis-substance, there were spots adjoining where the cells disappeared, and where the basis-substance increased in extent. These spots seemed to correspond to a process of healing and cicatrization. However the clinical signification of the process is not in question here.[1] The fact that fixed cells are transformed in a short time into basis-substance, has induced me to take up this question once more. And thus I have been led to examine the inflamed cornea of the frog on the heatable stage, with the result of showing that the branched cells are not fixed, at a temperature of about 36–38° C. [96°.8–100°.4 F.], but that processes disappear and reappear, and that the cells also alter their entire configuration.

In order to make this examination easily, I recommend injuring the cornea of the frog by sewing a thread through its centre, one to three days before the examination, according to the season of the year, and beginning the observations on the unheated heatable stage. As soon as branched cells have been found, begin to heat. At times we hit upon branched corpuscles that change even on the unheated stage; then again upon others which make only slight movements in spite of the heating; then again upon such as are transformed under our very eyes on the heatable stage into bodies without processes, resembling migratory cells; and finally upon such as gradually disappear from view, or, in other words, gradually assume the appearance of the basis-substance.[2]

In view of these observations, I can no longer maintain the opinion that the branched cells of the cornea are fixed. Moreover, I can no longer answer with an unconditional "yes," the question as to the existence of branched cells in the normal living cornea. I consider it advisable now to regulate my statements rigidly according to the results of observation. In the fresh cornea, I do not see any cornea-corpuscles; therefore it is undetermined whether they exist there at all. My experience admits of the statement that these corpuscles are formed under the influence of inflammation, or of reagents. A definitive conclusion on this subject is reserved for the future. But at all events it is now proved by direct observation that under the influence of the process of inflammation, basis-substance is transformed into branched cells, and, *conversely*, branched cells are converted into basis-substance; and herewith my theory of inflammation and suppuration is proved even to its ultimate consequences.

In the advanced stages of inflammation, still other phenomena may be observed on the heatable stage. Here and there I have seen a network as fine as that described above (page 52), in the case of corneæ painted with silver. But the network did not remain constant; it changed continually; threads appeared and disappeared again. In other places again I saw a fibrillar structure, and the fibrillæ, too, were not constant. At one time they would run together at a certain spot, so as to make it appear that there was a cell inclosed in the bundle of fibrillæ; at another time this coalesced mass would divide into fibrillæ again.

On the strength of these observations, I believe that I can now give a decisive answer to the question as to the nature and the import of the fibrillæ. As soon as I know that fibrillæ can appear and disappear again in the cornea

[1] Dr. Hänsell will treat of this in a separate article.

[2] These observations were made by me during the last weeks, just as the manuscript of this article was receiving its last corrections. I consider my observations thoroughly reliable, and for this reason publish them. But I am not quite sure of one thing; I do not know how soon the changes of the fixed corpuscles cease. These changes I saw with certainty (during the days from the 1st to the 20th of October, 1880), only about 15 or 20 minutes after excision.

under our very eyes, then there is no longer ground for the assumption that the cornea is fibrillar in the living state. I can now support my opinion by observation, which teaches that in life the normal cornea is not fibrillar, but homogeneous, and that in certain pathological conditions, or before death, it becomes fibrillar. Whoever now still asserts that the cornea or the cords of connective substance are constructed of fibrillæ, must prove his assertion.

In accordance with these explanations, I consider it advisable to separate distinctly the expressions *fibrillar* and *connective-tissue-like* (bindegewebig). A tissue which appears fibrillar to us, is not necessarily connective tissue. Hence it is also desirable to retain in pathology the plain term "fibrillar." If therefore the spinal cord is transformed into fibrillæ, we shall designate this as a *fibrillar degeneration*, or as a formation of *fibrillar tissue*. If the connective substance in the spinal cord is increased, this has by no means the same signification as fibrillar degeneration. Wherever the tissue has once definitively degenerated into fibrillæ, its function is forever destroyed. Swelling of the reticulated tissue of the white matter does not, however, exclude the possibility of a cure, as I have already remarked. This swelling—although, according to our present nomenclature, we call it proliferation of connective substance—is equal in significance to infiltration. The infiltration can degenerate, while the fibrillæ on the other hand are products of degeneration.[1]

All that I have said here in regard to fibrillæ, only refers to their occurrence in bundles. But there are tissues which contain fine isolated fibrillæ. Such fibrillæ may occur sparsely or abundantly. But each one takes its own direction, and where they occur abundantly they may even form a felt (Filz) of intersecting threads. The nature of all of these threads is by no means a settled question. At times they are processes of smooth muscular fibres, as *e. g.* many of the fibrillæ in the bladder of the frog; at times processes of transversely striped muscular fibres, as for example in the auricles of the frog; at times they are nerves, such as likewise occur in the bladder of the frog; at times again elastic fibres, *i. e.* cell-processes which have become resistant; finally they are very thin bundles of connective tissue (as *e. g.* in the interstices of the frog's muscle), which form a felt and may be designated as fibrillæ. These are indeed not very fine fibrillæ, but, as already remarked, very thin cords, which are commonly called (and perhaps justly) connective tissue, because of their wavy appearance and because of their reaction (becoming swollen) with acetic acid.

From the results of my most recent investigations, I no longer admit that the very fine networks which I have demonstrated in the cornea by treating it with lunar caustic, are present in the living state. Now, this matter of the reticular structure is a peculiar one. The living matter is nowhere chemically the same, whether in the cells or in the basis-substances. In both there are always mixtures. Besides the living matter, the cells contain a fluid; the basis-substance of bone contains in addition certain lime salts; and cartilage, probably some other substance which gives to it its peculiar appearance. Now when I mix a soft mass such as dough, with something else, such as shot, the doughy mass must contain pores in which the foreign particles are situated. A mass which has many such pores must be constructed like a network. Whether just these are the nets which I make apparent with silver, or whether there are others that only assume a new configuration after the use of the silver, is not a question of material importance. However, the transformation

[1] I draw the reader's attention here to the fact that the term "connective substance" is not yet sharply defined. I consider it possible that the connective substance of the nervous system represents only an undeveloped state of nerve-tissue, from which new nerve-tissue can be developed under favorable circumstances. I shall treat of this more in detail in the article already referred to on page 51.

already described of the white blood-corpuscle into a body resembling a salivary corpuscle, teaches us how rapidly such metamorphoses take place within the living matter. I must observe here that Heitzmann was the first to describe the net-like structure of the living matter, and to represent it schematically.[1] In principle Heitzmann is right, but practically I consider it unjustifiable, now as then, to conclude from the aspect of a network in certain spots of the stained basis-substance that this network was there in the living state. I also do not consider it admissible to conclude that because I can recognize a network in a living cell, all cells must have just such networks. I must moreover mention here that Kassowitz was the first to regard the basis-substance of the cartilage in its entirety as living matter,[2] altogether without reference to the recognition of a reticulated structure.

Epithelium and Endothelium.

Only two types of tissue still remain to be spoken of: Endothelium and Epithelium. The lining cells of serous membranes we call *endothelium;* that is, the lining cells of the peritoneum, of the pleura, and of the pericardium. We may also include here the intima of vessels. In all of these endothelial cells (as has already been described in detail), we can make the boundaries of certain nucleated fields apparent as brown lines, by using solutions of silver. These brown lines are called *cement-substances* (Kittsubstanzen) and *cement-lines* (Kittstreifen). As I have likewise already remarked, we may place the cement-substance on a par with the basis-substances. We know but little of the normal function of the endothelial cells. We know that the surface of serous membranes is moist, and we suspect that the endothelium plays a part here. Furthermore, on the basis of experiments by E. Brücke,[3] we suspect that the endothelium of the vessels assists in keeping the blood fluid. On the other hand, on the basis of experiments which Durante[4] has performed under my direction, I suspect that in consequence of disease of the endothelium of vessels after ligation, the coagulation of the blood in the neighborhood of the ligature is promoted. It has furthermore been supposed that the endothelium of the serous membranes served the purpose of absorption. However, we know now that the stomata discovered by Recklinghausen in the serous membranes, lead directly into the lymphatics by means of canals, and bring about absorption.

Endothelium has been most accurately investigated by E. Klein,[5] who has shown that single groups of endothelial cells proliferate even in the normal condition, besides doing so in a state of inflammation. As a result of inflammatory irritation, the endothelial cells of the bloodvessels as well as of the serous membranes return to their embryonic condition; they become softer again and more permeable; they swell, and their nuclei multiply. In this way suppuration of the endothelium takes place in serous membranes. The serous membrane is deprived of its endothelium. The pus-corpuscles fall into the serous sac, and appear there in the so-called exudation as pus-corpuscles. Whether and how capillaries suppurate, I know not. But there is not the slightest doubt that the intima of arteries and veins can suppurate. In chronic inflammations, the endothelial cells grow; they are prolonged so as to form cords, which resemble cords of connective tissue. The cords of tissue produced from the endothelium, form the so-called *false membranes.*

[1] Wiener Sitzungsberichte, 1873, Bd. 67; 3te Abth.
[2] Wiener mediz. Jahrb. 1879–1880.
[3] Virchow's Archiv, N. F., Bd. xii.
[4] Med. Jahrbücher, 1872, S. 143.
[5] Anatomy of the Lymphatic System. London, 1875.

They cause the firm adhesion of the serous membranes, whence is derived the name *adhesive inflammation* (John Hunter).

The fact that the capillaries send out offshoots and thus produce a new vascularization, I have already mentioned.

Epithelial Cells are likewise separated, or rather united, by narrow strips of intermediate substance. Here, too, brown boundary lines become visible by staining with silver. On many epithelial cells (cornea, cutis, and others), fine threads have been observed (*Prickle cells*, Max Schultze[1]), which are connecting threads between two neighboring cells, as has been shown by Bizzozero.[2] Accordingly, epithelium constitutes a tissue similar to the connective substances with this exception, that the amount and structure of the basis-substances, and naturally also the form and function of the cells, are different.

The functions of the epithelial cells are extraordinarily varied. In the glands, the main task of secretion falls to their lot. They must therefore be adapted to the multifarious actions of the various glands. The part which is played here by the mechanical action (enlargement and diminution) of the cells, I have already heretofore described. In the intestine, the epithelial cells are certainly concerned in the process of absorption. Spina is about to publish an article in which he shows that in this process also, the mechanical action of the cells (swelling and subsequent diminution) comes into play. But of the function of by far the greater portion of epithelial cells, those of the cutis, the intestine, the air-passages, and the urinary organs, we know very little. In general, it is said that they serve as a cover, as a protective lining, and are present on the mucous membranes for the production of mucus to keep the surface viscid. The ciliated epithelium is believed to serve for the removal of fine particles. But these statements are surely not exhaustive.

The pathological processes in the epithelium of certain organs are better understood. Slight stimuli suffice to excite a secretion of mucus in certain epithelial cells, though it is certain that the vascular system co-operates here. Acute catarrhal processes, when they appear in otherwise normal mucous membranes, commence, as a rule, with a profuse, watery transudation, and only at a later period does the secretion of mucus begin. The profuse watery transudations surely come from the blood, and even the mucus must partly come from the same source, inasmuch as we may assume that the cells must draw fresh (fluid) material from the blood in order to secrete as profusely as they are wont to do in catarrhal processes. But the conversion into mucus of the material drawn from the blood, must certainly be performed by the epithelium. During this conversion, the cells are abnormally active, and as a rule we have cell-proliferation accompanying the process. As a general thing, also, we find single amœboid cells which are called *mucus-corpuscles* from the locality in which they occur. If the production of cells increases, the mucus is gradually changed into pus. But there are intermediate stages, in which indeed there are already produced very many amœboid cells, but in which there is also still a production of mucus. Finally, the production of mucus may cease entirely, and pus alone make its appearance. But then we may presume that the epithelium as such has been destroyed, and that embryonic proliferating cells have taken its place, or, in other words, that the epithelium has returned to its embryonic condition.

In the case of epithelium, this return frequently takes place in a central portion of the cell, when the peripheral portion of its body remains rigid and sterile. This species of cell multiplication is termed *endogenous*. It was first observed by Remak in the epithelium of the urethra, in gonorrhœa. As is seen, *endogenesis* is nothing else than a cell formation by division. Only

[1] Medic. Centralblatt, 1864.

[2] Medic. Centralblatt, 1871, S. 482.

here a central portion of the cell divides. The peripheral portion of the body forms a hull, a capsule, a matrix in which young cells lie. But the young cells are nothing else than portions of the old body which have become amœboid. The capsule bursts, and the young cell or the several young cells which were in it, are liberated and appear on the surface as pus-corpuscles. But I must state here that endogenesis does not always take place in an old resistant capsule. I would recall the fact that, in the embryo, blood-corpuscles are produced by endogenesis. And here the capsule is still a young cell-body, and even will become a contractile vascular wall, as has already been shown. Finally I wish to remark that epithelium does not always reproduce itself by endogenesis. I have already seen, sufficiently often, examples of complete division in epithelial cells, and believe therefore that they can return wholly to the embryonic condition, and undergo total division. The difference probably depends on the condition of the peripheral zones. If these are very resistant, as appears to be the case in cells situated superficially, then endogenesis prevails. The most superficial layers of epidermis seem to be incapable of proliferation. Here the life of the cells seems to have reached too low a grade, if it be not entirely extinguished. But the next deeper layers of cells show a multiplication of nuclei in conditions of irritation. The principal proliferation (new cell-formation) certainly takes place in the deeper layers of cells in the so-called rete Malpighii.

If the suppuration of mucous membrane has proceeded so far as to finally lay bare the substantia propria, and the pus is now produced on this part, we call the diseased surface an ulcer. As long as the epithelium is preserved, the superficial inflammatory process of the mucous membrane may still be called catarrh, although to do so is not quite correct. In a strict sense, catarrh is present only as long as the secretion consists of mucus. If the (former) mucous membrane produces pus only, it is no longer a mucous membrane, and can no longer be in a catarrhal state. We are not so particular, however, about fixing the limits, because frequently we cannot at all decide whether the secretion is entirely devoid of mucus and consists only of pus. It is therefore preferable to regard the condition of the mucous membrane as the determining point, and to draw the line between catarrh and ulceration by using anatomical data as the basis of our judgment. The expression catarrhal ulcer, employed by pathological anatomists, naturally only points to the genesis of the ulcer. A catarrhal ulcer is one which is the result of the catarrhal process. But one and the same spot cannot be the seat of catarrhal and ulcerative processes at the same time.

Healing by First Intention and Healing by Granulation.

Ulcers as well as cavities of abscesses heal by the formation of granulations. We call the new formations "granulations," because of the little warts or protuberances on the surface of the ulcer and the interior of the abscess-cavity respectively. Why these new formations appear here in the form of little protuberances is not known. These little protuberances consist of cells which are designated as *granulation cells*. But between the cells we find layers of intermediate substance—now broader, now narrower. The cells, added to the intermediate substance, form a young tissue from which the cicatrix is produced. The matrix for this young tissue is in the bottom of the ulcer and in the lining of the abscess-cavity respectively. The granulations are not developed from the normal tissue, however, but from the tissue infiltrated by inflammation. We know, now, what the word infiltration signifies. We know that infiltration consists of a swelling of the

network of cells, produced at the expense of the basis-substance. This swelling means the extension of the cell-borders—a conversion of basis-substance into cell-body. At the same time the cells themselves become capable of proliferation. They divide, and form pus, as long as the process is an acute (stürmisch) one. Finally, a portion of the infiltrated tissue is disintegrated. The process becomes less intense. The disintegration stops, but the growth of the cells continues. New boundary lines are also formed, but the cells do not separate. At the boundary lines intermediate substances appear, and herewith the genesis of tissue is begun.

Suppuration, however, does not cease upon the commencement of tissue-genesis. On the most superficial layers of the new tissue a real cell-partition still takes place, and pus is formed. A moderate production of pus on the surface of the ulcer is, as physicians know, not at all an impediment to recovery. But the suppuration must not become so profuse as to make the newly-formed tissue disintegrate; for in that case a replacement of the destroyed tissue could not take place. In recent, carefully-nursed wounds following operations, tissue-genesis predominates over suppuration. If the process be hastened by warm applications, we increase the suppuration, indeed, but we also hasten the replacement of the lost tissue, which could not take place were the suppuration to predominate. In old, badly-treated ulcers, suppuration and tissue-genesis are about evenly balanced, or suppuration even may predominate. In such cases the ulcer does not heal, or may even extend more deeply. In other instances, again, the tissue-genesis predominates to such an extent that the granulations grow beyond the level of the normal surface, as "*proud flesh.*" Finally, in other cases, cell-growth in general is but slightly stimulated, and here also the ulcer does not heal, even though it does not suppurate. In this last instance, too, warm poultices can stimulate growth.

It is probable that the varied course of the healing process depends at least in part on the fulness of the vessels. New vessels grow along with the tissue-genesis. The new tissue, as it is said, becomes vascularized. I am unable to say anything on the mode of this new formation. Statements in reference to it are indeed not wanting; but they are based on such faulty microscopical examinations that I do not consider it worth while to take notice of them. It is not likely that bloodvessels are produced in granulations otherwise than in the embryo, and in certain inflammatory and non-inflammatory new growths, in which their genesis has been accurately determined (see pp. 7 *et seq.*). That the vessels of granulation tissue consist of young, soft, easily permeable and easily lacerated tissue, may be inferred from the circumstance that granulating surfaces bleed on the slightest provocation.

The definitive cure of an ulcer cannot result from the granulations alone. A covering of epithelium must be developed. This covering proceeds either from the margins, that is, from the place where the epithelium is preserved, or from the bottom of the ulcer, if there are glands still preserved there. Finally, the covering may be artificially produced[1] from transplanted pieces of cutis. It is self-evident that the transplanted portion must still be covered with cells of the rete, for the protection of which, moreover, the uppermost cells are also necessary. From a theoretical point of view, the transplantation of rete and epidermis ought in every respect to be sufficient to furnish a new centre for the production of a new covering of cells in the ulcer, and this has in fact been confirmed by experiment. But whether it is desirable in prac-

[1] As first practised by Reverdin. See Gazette Médicale de Paris, 1866, No. 26. Report of Marc Sée.

tice to transplant only epidermis cells in place of the entire cutis, I do not know. The *rationale* of transplantation is to be found in the fact that epidermis is more readily developed from epidermis than from the granulation tissue which arises from connective tissue. Hence, if the ulcer be very large; if the pushing forward of epidermis from the margins have become insufficient; we transplant epidermis to the central portions of the ulcer in order to furnish new starting points from which the healing process can spread.

Healing by the formation of granulation tissue is also called *healing by suppuration*, or *by second intention*, in contradistinction to *healing by first intention* (John Hunter). In the process of healing by first intention, there is no suppuration; the margins and surfaces of the wound unite directly. Notwithstanding this, however, the old tissue must soften again, and become capable of growth, else a definitive union would never occur. Investigation has also taught that new processes are sent out by the cells from one surface of the wound into the other; and, besides, that in the very small space between the surfaces of the wound there are young cells to be found. Accordingly, from a theoretical standpoint, the difference between healing by first intention and second intention is only quantitative. From a practical point of view, the matter is indeed different. For in healing by first intention the loss of substance is almost imperceptible, and the wounded organ need, therefore, suffer no disturbance of function worth mentioning. But healing by suppuration always presupposes a loss of substance, and the tissue which replaces the old one is of a new kind, is different; is cicatricial tissue, and cannot assume entirely the function of the former one. In the cutis, it is true, the replacement of certain small regions by cicatricial formations is of slight importance; but in the cornea, for example, if suppuration have occurred, the loss is irreparable. For cicatricial tissue is not cornea tissue; cords, fibrillæ, and cells, are indeed present in cicatricial tissue, but not that homogeneous mass which I have described as existing in the cornea.

Regeneration.

A real regeneration as regards form and function, is known to us (in man and mammalia) only in the case of nerves and muscle.[1] Divided nerves heal under favorable circumstances in such a manner as to completely restore the connection between the central nervous system and the periphery. In view of new researches made by Jul. Wagner[2] on this subject, I must pronounce the older statements on nerve-regeneration inaccurate. Regeneration of the nerves depends on a chronic inflammation. The medullary layer disappears. Axis-cylinder, network of the medullary layer, and Schwann's sheath, are converted into new morphological elements. This change occurs in the central as well as in the peripheral extremity. By the growing together of these new morphological elements (just as in healing by first intention), new nerve-tissue originates.

The regeneration of nerves gives us probable proof that tissue-genesis can be influenced by the central nervous system. For a return to the normal condition, as it occurs in the case of a nerve, proceeds apparently only under the influence of the central nervous system. If the union of the two extremities be prevented by the excision of a sufficiently large piece, then it is presumed that the formation of new nerve-tissue in the peripheral extremity

[1] I do not dwell farther on the regeneration of muscles. It is only a matter of the development of the old fibres.

[2] Not separately published by him; I have reported thereon in my Lectures.

will also be prevented. Positive and unequivocal proof that the growth and nutrition of tissues in general are influenced by the central nervous system, has, however, not as yet been furnished. We are, it is true, acquainted with affections of tissues which are due to diseases of the central nervous system; such are acute bedsores in certain severe central diseases, and progressive muscular atrophy in connection with disease of the ganglia in the anterior horns of the spinal cord (Lockhart Clarke, Charcot). Recently, Ad. Jarisch[1] has discovered a very important relation between diseases of the skin and diseases of the spinal cord, likewise in the region of the anterior horns; the affection in one instance was a case of herpes iris, and in another a case of pemphigus, though in this the relationship was less pronounced. I have carefully examined the specimens in question. The disease of the anterior horns of the spinal cord was quite evident. These data, it appears to me, are very important for pathology. But whether we have to deal with centres which directly influence the tissues—that is, with so-called trophic nerves—or with vaso-motor centres, is not known. Disease of the vaso-motor centres is certainly adapted to provoke pathological disturbances in peripheral organs, *i. e.*, in the region of distribution of the affected nerves.

Non-inflammatory New Formations.

All tissue-changes which are accompanied by active hyperæmia, that is by the clinical phenomena of inflammation, can also run their course without hyperæmia. Under such circumstances, we call the tissue-metamorphosis a *neoplasm*. Since such neoplasms in the majority of cases appear in the form of tumors, they are also simply called *tumors*. Inasmuch as it was imagined that these new formations were in idea and in structure foreign to the human organism, and not characteristic of it, they have been also called *spurious formations* or *pseudoplasms*. From the fact taught by clinical experience, that some of these new formations are more or less injurious to the organism, they have also been divided into *benign* and *malignant*. On the other hand, they have also been classified according to form, consistence, location, genesis, structure, and I know not what other principles. The scientific value of such a classification is very slight. In modern times it has degenerated wholly into child's play. It does not seem to me worth while to refer here to the literature of the subject, while we are considering general questions. Neoplasms [non-inflammatory new formations] are much richer as regards forms of tissue than are inflammatory new formations. True, we have here again only cells and basis-substances which constitute the new formation; but the size and form of the cells, as well as their mutual connection with and relation to the basis-substance, are more varied. Moreover, the pathological non-inflammatory new formation can imitate every form of normal tissue, which never happens in the case of inflammatory new formations. In inflammation, pus, fibrillar tissue, cicatricial tissue, and epidermis, can be produced; and, moreover, a regeneration can proceed from a fixed matrix, as in the case of nerves and muscles. Neoplasms, on the contrary, can imitate all forms of normal tissue without proceeding from a matrix of the same kind. In the midst of connective tissue, or of muscle, epithelium cells and even fully developed glandular tubes can be produced. In ovarian cysts, teeth and hairs may be developed. In the case of inflammatory, as well as of non-inflammatory, new formations, the tissues return to their embryonic condition, in which they are capable of proliferation. In non-inflammatory new formations, however, the

[1] Sitzungsber. der Wiener Akad. 1880.

impulses to growth, even if not always more powerful, still appear to be more lasting and more varied than in inflammation. Are these impulses perhaps dependent on residues of intra-uterine life? on residues that were latent, and now have become active from some favorable circumstance? are they perhaps due to particles carried away by the blood or lymph stream, which adhere somewhere, and, as it were, infect the tissue? Finally, is it perhaps the general condition of the fluids which favors the new formations? These are all questions which have until now only been speculated upon.

Degeneration of the Tissues.

Fatty Degeneration of tissue can be brought about in two ways:—

(1) In certain cells fat is developed, and collects to form a drop. This drop of fat presses the cell-body towards the periphery; of the body, only a peripheral zone, surrounding the drop and also containing the nucleus, remains. The normal prototype of this form of degeneration is shown in the collections of fat in the subcutaneous tissue, and in other normal deposits of fat.[1] Pathological types of fatty tissue are presented in the case of the lipoma, and in the excessive development of fatty tissue in normal localities.

(2) The normal type of the second form of development of fat presents itself in the epithelium of the mammary glands. Here the fat is deposited in the form of granules, or little drops, which, relatively to the cell, are very small. The entire cell, at every depth, appears filled with granules. During the first days of lactation, portions of the cells containing fat-granules separate from their matrix, and are expelled with the milk. Such bodies are called *colostrum-corpuscles.* Similar fatty degenerations probably occur in the cells of the sebaceous glands. Certain processes in the hepatic cells are on the boundary line between a normal and a pathological production of fat. Here, too, the fatty change consists in the appearance of small fat-granules within the liver-cells. But the hepatic cells may contain a normal quantity of fat-granules, and may also undergo extensive pathological fatty degeneration. In a state of disease, all cells and all living derivatives of cells may undergo fatty degeneration.

The essence of fatty degeneration consists in a production of fat by the cell. The cell can transform constituents of its own body into fat, or, differently expressed, constituents of the cell can be converted by chemical decomposition into fat (and into some other products of decomposition). The cell can at the same time continue to live. It is true, the fat-granules act as foreign bodies on the cell-body; hence the presence of fat-granules probably involves a disturbance of function; but it does not exclude a continuation of this function. If considerable portions of the cell are transformed into fat, the disturbance naturally increases. Under no circumstances, however, can we consider the fatty cell, or of course the fatty muscle, as incapable of recovery. The fat-granules can be absorbed; they can also be expelled, and the remaining living matter can continue to perform its function and can even recover entirely by means of tissue-metamorphosis. I say it can, if the conditions are favorable; especially if the cause of the progress of the fatty degeneration ceases to act. If the fatty degeneration makes headway, it may finally interfere so much with the performance of function as to cause death; if, for example, it implicates the substance of the heart.

[1] It is a matter of dispute whether adipose tissue is a tissue of its own kind, or whether it is altered connective tissue.

Amyloid Degeneration undoubtedly depends, as was first asserted by Virchow,[1] on a metamorphosis of the tissue to that peculiar substance which we call amyloid. Amyloid indicates that it is related to amylum. This suspicion is based on the reaction with iodine, discovered by Meckel and Virchow.[2] The reliability of the iodine reaction has been questioned, but Böttcher reasserts that it is the best of all. He employs a mixture of 25 centigrammes of iodine, 50 of iodide of potassium, with 100 cubic centimetres of water, and adds dilute[3] sulphuric acid. More recently, methyl compounds have been recommended. This reagent stains the amyloid substances red, but the healthy tissue blue. But this test has also been reported as unreliable by Kyber.[4]

With regard to the chemical composition of the amyloid substance, E. Ludwig has favored me with the following data:—

According to the analyses of Friedreich and Kekulé, as well as those of Kühne and Rudneff, it shows a composition very nearly approaching that of the albuminous bodies. It is soluble in concentrated hydrochloric acid, from which water precipitates a body having the properties of syntonin hydrochlorate. Amyloid substance is soluble in potassa or soda lye, and the solution has the properties of an alkaline albuminate. E. Modzejewski obtained tyrosine and leucine as products of decomposition of the amyloid substance, by acting on it with boiling dilute sulphuric acid; he supposes that the amyloid substance gives the same products of decomposition as albuminous bodies. From the putrefaction of amyloid substance Th. Weyl obtained the same products that fibrin yields in putrefaction. It is apparent from all of these observations that the amyloid substance is very closely allied in its chemical properties to albuminous bodies.

These data are still too meagre, however, to permit of conclusions being drawn as to the nature of the process. But we may be sure of one thing. The amyloid degeneration cannot be compared to the inflammatory metamorphosis of tissue. The amyloid constituents of tissue are lifeless. The cell, the capillary wall, or the basis-substance which has become entirely changed into amyloid matter, can no longer take active part in the functions of the organism. The same, it is true, also holds good for those constituents of the tissue which have undergone fatty degeneration. But it is important to lay stress upon the difference between the two. Fat can be more easily dissolved and absorbed. The amyloid substance, however, seems to burden the tissue permanently. Hence a cure (*restitutio ad integrum*) of amyloid organs is hardly to be thought of.

Calcareous Degeneration.—Just as the tendency to produce fat resides in certain tissues, so other tissues again have the property of depositing lime salts. Bone and cartilage belong to this class. Inasmuch as cartilage is converted into bone,[5] it must deposit lime salts in its basis-substance. But cartilage calcifies sometimes (as for example under the influence of slight inflammatory stimuli) without being converted into bone. Of pathological calcifications of other tissues, too little is known besides the mere fact that they do occur, to warrant my considering them here.

Colloid Degeneration.—In conclusion, I present some remarks with regard to colloid degeneration, for which I am likewise indebted to E. Ludwig.

The colloid-substance in its chemical properties approaches most nearly to mucin, but differs therefrom by its solubility in acetic acid. Eichwald regards the colloid

[1] Charité Annalen, 1853.
[2] Virchow's Archiv, Bd. viii., 1854.
[3] Said to be seven per cent.
[4] Virchow's Archiv, Bd. lxxxi., 1880. Kyber also praises the reaction with iodine and sulphuric acid.
[5] The occurrence of a direct transformation of cartilage into bone is now probably quite certain: but this is not the only method of its formation.

material as a modified mucin, representing a transition from mucin to muco-peptone. Wurtz examined the gelatin from a colloid cancer of the lung; it was insoluble in water, and by evaporating to dryness was converted into a white laminated mass, which gave, after extraction with alcohol and ether, a white powder that in turn again swelled into gelatin. Potassa and soda lye dissolved the gelatin, and acetic acid precipitated it from solution. An elementary analysis of the dry substance gave 48.09 per cent. of carbon, 7.47 per cent. of hydrogen, 7 per cent. of nitrogen, 37.44 per cent. of oxygen. This composition varies considerably from that of all known albuminous bodies; it approaches the composition of chitin. It is probable that the colloid material can be converted into mucus.

INFLAMMATION.

BY

WILLIAM H. VAN BUREN, M.D., LL.D.,

PROFESSOR OF THE PRINCIPLES AND PRACTICE OF SURGERY IN THE BELLEVUE HOSPITAL MEDICAL COLLEGE, NEW YORK.

General Considerations regarding Inflammation. Definitions.

The pathology of inflammation, as interpreted by the methods of the histologist, having been fully set forth in the preceding article, it remains to describe this complex but important condition, so constantly under the eye of the surgeon, from the standpoint of clinical observation.

The definitions of inflammation furnished by the latest teachings of science, although their correctness is not disputed, do not convey the full significance of the term as employed in the ordinary language of the surgery of the day. In this, supreme importance is ascribed to the objective symptoms of pain, heat, redness, and swelling, as originally enumerated by the Roman surgeon Celsus in his definition of inflammation which has become classical; and the idea of fiery excitement which suggested the early use of the Greek adjective "phlogistic," and its Latin synonym "inflammatory," are always present in the mind. Thus, if a wound is described as "inflamed," the idea intended to be conveyed is that some of the cardinal symptoms just mentioned are present, whereas simple primary union may take place, or even granulations and suppuration may go on, without either pain, heat, redness, or swelling in a noticeable degree; and yet primary adhesion, granulation, and suppuration are certainly legitimate features of the inflammatory process as we now comprehend it. The definitions heretofore proposed are more or less imperfect, in consequence of the obscurity which belongs to the subject. Those entitled to most respect simply describe inflammation as the aggregate of the phenomena which are set in action by any lesion of the organism affecting its tissues locally, provided, of course, that the tissues involved have not been killed outright. It is obvious that the phenomena which attend the kindly healing of a simple incised wound are not fully recognized, in the *popular* sense of the word, as belonging to the same "series of changes" which culminate in the more violent manifestations of inflammation and result in suppuration, ulceration, and possibly gangrene. These latter are regarded as belonging to true inflammation.

To reconcile this absence of conformity, which is readily explained by a glance at the recent advances in the science of surgery, Sir James Paget has employed the phrase "process of repair" to designate the milder phenomena of inflammation as they occur in healthy, healing wounds; and more recently Samuels has described the reparative process of Paget as the "constructive" phase of inflammation, reserving for suppuration, ulceration, and gangrene the term "destructive." These expressions, which indicate truly the results of the process, recognize fully an identity of nature.

The science of human pathology, which took its origin in the study, after death, of the anatomical changes of the diseased organs and tissues of the body—morbid anatomy, as it is usually called—was inaugurated mainly by the French school, early in the present century. Its first great advances established the identity of what was called inflammation, as manifested on the surface of the body and in wounds, with similar conditions affecting its internal organs, an identity which had never been demonstrated. Under the influence of the plausible theories of Brown and Broussais, inflammation, thus advanced to a more extended domain, came to be considered as the most important of all the pathological forces; an uniform termination was affixed to the names of inflammatory diseases—*itis*—significant of the afflux of blood to the inflamed part—"*itio in partes;*" and the treatment of the diseases thus distinguished, which formed, according to their assumption, a large majority of human maladies, was of necessity, following these premises, intrinsically antiphlogistic. The period is within the memory of the writer when it was the dominant doctrine in the schools that inflammation, in some form, constituted the essential factor in most diseases.

The application of the microscope to the study of morbid anatomy subsequently demonstrated, by degrees, the existence of a variety of degenerations and other morbid changes constantly taking place in the tissues and organs of the body, which were evidently unconnected in any way with inflammation. Through the advance in more accurate knowledge, inflammation has therefore ceased to be regarded as such an omnipresent disease; it has come to be considered, in fact, as in no respect an essential disease, but rather a condition liable to be provoked in the organism by certain harmful influences, called for convenience the *causes* of inflammation; a condition located mainly in the apparatus of nutrition, affecting a limited area, and consisting in a temporary perversion of the mechanism of nutrition from its natural and regular order, which is characterized by a series of phenomena already described by the histologist, and to be hereafter considered from a clinical point of view under the title of *symptoms* of inflammation.

It should not be, therefore, a matter of surprise that the terms employed in treating of inflammation, including indeed the word itself, have been gradually changing their signification in accordance with the growth of more precise knowledge; and, lest the mind should be influenced by the more vague and pretentious meaning heretofore attached to these terms, the fact of this change in signification should be held in constant remembrance. The term inflammation will be employed in the ensuing pages as including the series of textural changes—microscopic, as well as macroscopic—which take place in living tissues after they have been subjected to injury. For the sake of convenience, the term "constructive" will be applied to the phenomena of afflux, exudation, cell germination, the formation of new capillary vessels, and the development of cicatricial tissue—in other words, to the inflammatory phenomena which constitute the simple uncomplicated "process of repair;" whilst the additional presence of suppuration, ulceration, or gangrene, and all other harmful complications of the process, will be included under the term "destructive."

In this connection it may be observed that inflammation has heretofore been treated of by systematic writers as a *disease*, with certain characteristic features, and tending to certain "terminations." The convenience of this mode of handling the subject is obvious; but its scientific correctness is open to question. In popular, and also in professional language, it is common to speak of "an attack of inflammation" as of an attack of tetanus; and the remedial measures employed in its treatment have been habitually designated as "antiphlogistic." Now, inflammation, although presenting in some of its

phases well-marked features which in a popular sense might justify the use of this term, does not possess the essential qualities of a disease in the more precise language of science; and it cannot be spoken of as a disease ontologically. In very many, indeed in most of its phases, it is a benign, healthful process to which, even in its popular sense, the appellation of disease would be regarded as inapplicable.

It is better, therefore, with our incomplete knowledge, to assume that inflammation is a process more or less abnormal, or a condition—not even in a majority of instances a morbid condition—presenting as its characteristic features a series of textural changes typically uniform in character, although varying widely in aspect, and leading to different results according to the nature and degree of persistence of the causes which have given rise to it. This designation is as proper, and as intrinsically correct, as when the word condition is applied to a local numbness, to intoxication, to pregnancy, or to the moribund state.

When the causes which have given rise to inflammation cease to act, the features which characterize the condition disappear; it has no inherent power of continuance beyond that which has been impressed by injury of some sort upon the local nutritive machinery. The textural changes which belong to the condition, as far as they are objective, constitute its *symptoms;* as far as these changes are subjective, they constitute its *pathology.* The means which have been found to modify these symptoms favorably, or which, through a knowledge of their course, may be rationally expected to lead to such a result, constitute its remedies, and will be considered under the head of *treatment.*

These considerations occur naturally to the surgeon familiar with the clinical aspects of inflammation in any attempt to bring them into causal relation with the histological phenomena by which they are explained. Until this relation is established there is no solid basis from which to reason in studying its symptoms in detail, and its treatment is of necessity entirely empirical. Histology teaches us that the essential features of the inflammatory process are, an increased afflux of blood to the affected part, with an exaggerated tendency to cell proliferation and tissue formation. A knowledge of the mechanism of this process affords the only rational explanation of the various manifestations which it presents to the unaided eye; and, when combined with clinical observation and experience, this knowledge gives us all the power we can safely exercise in favoring its *constructive* tendencies, and in averting or controlling its proclivity to *destructive* results.

It may be proper to remark, in this connection, that the destructive phases of the inflammatory process do not apparently arise from any noxious quality inherent in the process itself, but, rather, from the intrinsically defective power of the human structure to resist and repair injuries. Naturalists have taught us that this power of repairing injuries exists in a much greater degree in the lower animals than in our complex organisms. The destructive phases of inflammation are also explained in some degree by the degradation in vital quality of our tissues which results from unhealthful habits of life, and surroundings defective as to hygiene; by the more aggravated character of injuries rendered possible by human ingenuity—as exemplified in gunshot wounds; and by ignorance of the real nature and scope of our reparative powers, and the means by which they may be aided and supplemented. The truth of the last averment is rendered probable by the increased power of repair, the greater rapidity with which the reparative process is accomplished, and the remarkable infrequency of the destructive symptoms of inflammation manifested in wounds which have been subjected to judicious drainage and treated early and skilfully in accordance with the *antiseptic* method.

The present account of inflammation will include its *causes*, *symptoms*, *varieties*, *consequences*, and *complications*—viewed especially in reference to its management in the practice of surgery.

Causes of Inflammation.

The *causes of inflammation* determine, in a great degree, the attitude to be assumed by the surgeon in its judicious treatment, for they exercise a direct influence upon its constructive, or destructive, tendency; there is, therefore, no department of the subject more worthy of careful study.

Irritation and Injury.—In accordance with doctrines which were long dominant in medicine, "irritation," acting upon any of the tissues or organs of the body, was held to be the immediate exciting cause of inflammation; and the development of irritation in any locality was supposed to invite the flow of blood towards it—the first step in the inflammatory process. Hence the apothegm "*Ubi irritatio, ibi affluxus.*" The term "irritant," habitually employed as synonymous with "an inflammation-producing agent," has in more recent times given place to "injury." The latter has become a technical term in surgical pathology, signifying *that which is capable of impairing the vital quality of the tissues.* It is used in this sense in a form of definition of inflammation, which has become classical: "the series of changes that follow injury, provided the injury has not been so severe as to cause the death of the part" (Burdon Sanderson). An "injury," then, may be regarded as competent to inaugurate the "series of changes" that constitute inflammation.

It is worthy of notice, as illustrating the purposive tendency of inflammation, that, at its inception, if not in its later phases, it is mainly, if not entirely, *constructive.* It can hardly be doubted that the "series of changes" following a lesion which has not absolutely destroyed textural life, have for their object the repair of the lesion; this is apparently demonstrated by the result, which, if the inflammation does not transcend certain limits, is almost invariably curative.

There is a limited analogy, as to their immediate consequences, between the influence of a surgical "injury," and the fertilizing of an ovum; both stand in the relation of cause and effect to a sequence of changes which lead directly to cell proliferation and tissue formation. Rindfleisch tells us, in fact, that he prefers to study the process of embryonic cell development, under the microscope, in inflamed tissues.

Classification of Causes.—As employed in connection with the causes of inflammation, the term injury includes the endless variety of wounds, hurts, and lesions, of every possible nature, to which our organisms are exposed. The manifold sources of injury are advantageously arranged in three classes:—

(1) Those arising from physical force or mechanical violence—as cuts, stabs, fractures of bone, dislocations of joints, and laceration, bruising, or crushing of limbs, or of internal organs.

(2) Those arising from irritating or destructive chemical action—as from heat in any form, such as burns and scalds from strong acids, or caustic alkalies, from the action of cold, etc.

(3) Those arising from poisonous infection, as from the venom of insects and serpents, from a virus, as of glanders, or syphilis, from the miasm due to the infinite diffusion of poisonous microscopic organisms, or their germs.

Many of the individual injuries thus classified have been recognized in all times as determining causes of inflammation. Others, again, and mainly

those of the third class—the injurious micro-organisms—have only recently been brought under the cognizance of the pathologist as the immediate determining causes of the more destructive phases of the inflammatory process. There is promise of great benefit to humanity and of equal credit to surgery in the fact that its pathology has been enriched, though the philosophic acumen and admirably patient research of one of its own devoted students, by the demonstration of this still novel cause of inflammation; and the gain to humanity and to surgery has been incalculably magnified by the correlative discovery of effective remedial measures, actual and preventive, for the various forms of destructive inflammation thus traced to their source.

John K. Mitchell, of Philadelphia, before 1849, expressed a strong belief in the cryptogamic origin of the poisons generally known as miasmata, and ably defended the theory that most malignant fevers were due to this source.[1] Pasteur, in 1865, discovered the cryptogamic micro-organism which caused the epidemic silkworm disease in France, and demonstrated its direct agency in perpetuating the disease. The next year, Lister, assuming by induction that a similar source of poisonous infection might be capable of preventing the normal process of repair of wounds, inaugurated a course of experimental research which has, in the opinion of many, amply demonstrated the proposition. As this interesting subject will be discussed in a separate article, it is not necessary to pursue it here beyond the recognition of poisonous germs as a pregnant cause of inflammation in its worst forms.

Following the general classification which has been laid down, we shall study, with concurrent details, some of the typical causes which clinical observation has shown to be capable of exciting inflammation, seeking, in each, for indications as to the means by which, ultimately, this condition may be prevented or controlled. In the first place, however, it will be necessary to notice certain general considerations which necessarily form part of a study of the causes of inflammation; and, also, to define the meaning of certain terms commonly used in treating of this subject.

Most systematic writers speak of inflammation as *traumatic*, or *idiopathic*, in accordance with its origin from obvious injury, or the reverse—and, when there is no discoverable cause for its occurrence, it is assumed to arise spontaneously.

The terms *idiopathic* and *spontaneous*, as applied to inflammation, are convenient, but they are of doubtful accuracy. It is not certain that either of them is in any case correct, in a scientific sense. It is exceedingly improbable that the series of textural changes of which the inflammatory process is believed to consist can be set in action without a provoking cause. These terms have come to be habitually used under the assumption that inflammation is a disease. In fact, they are only admissible as signifying that the source of origin of the inflammatory condition is not, at the moment, demonstrable.

Again, the terms *internal* and *external* inflammation, as applied to the condition when it occurs in the interior of the body, or upon its surface, are employed, somewhat vaguely, as synonymous with *medical* and *surgical*, in accordance with French nomenclature, which designates medical pathology as *internal*, and surgical pathology as *external*. This use of words perpetuates the idea that there is a radical difference between medical and surgical pathology; an idea which is no longer tenable. There has been a time when the surgeon was content to leave the examination of internal organs to the physician, before as well as after death, but, since the functions of the surgeon and physician have become so inseparably blended as they are at the present

[1] On the Cryptogamous Origin of Malarious and Epidemic Fevers. Philadelphia, 1849.

day, this fashion has passed away. The expert (as he is now properly styled) in either of these branches of medicine finds his knowledge advantageously supplemented by deferring to the histological pathologist, who, in the exercise of his peculiar methods, is also an expert in the more accurate interpretation of the appearances of morbid anatomy.

To illustrate the correlation of medicine, surgery, and histology, it may be mentioned that Curling first called attention to the relation between burns of the surface of the body and the ulceration of the duodenum which so often accompanies them; and Erichsen emphasizes the fact that death ascribed to the shock of injury and to exhaustion, is often explained, in the dead-house, by the discovery of laceration of the liver. Jaccoud and Ferrier have obtained most of their illustrations of intra-cranial pathology from well-observed cases of surgical injuries of the head. The histologist has taught us that senile gangrene, formerly attributed to arteritis, is in fact caused by calcific degeneration of the arterial coats, and by thrombosis and embolism; and that arteritis, formerly supposed to be a common occurrence, is in reality a rare condition.

Predisposing and Exciting Causes.—Systematic writers usually lay much stress upon the distinction between what are called the *predisposing causes* of inflammation and its immediately *exciting* or *determining* causes. An example will illustrate the meaning of these terms: A growing boy, overheated by exercise, goes into the water to bathe, or throws himself on the ground in the shade to rest. During the following night he is awakened by a severe pain in the thigh, which is continuous as well as severe, and finally results in a necrosis from limited osteo-myelitis. In such a case, which is of common occurrence, the activity of the nutritive process in the rapidly growing bone of the adolescent, and exhaustion incident to the fatigue incurred, are the *predisposing* causes; and the rapid abstraction of heat from the body by the cold water, or the cool earth—the chilling, in fact—is the *exciting* cause of the inflammation. These two classes of causes are also designated as *remote* and *proximate*. Most of the sources of injury classified above are examples of proximate or exciting causes.

Predisposing Causes of Inflammation.—The most obvious and important of the remoter causes which predispose a part or an organ to take on the condition of inflammation, is *defect in quality of the blood*. When we reflect that all the organs and tissues of the body are, as it were, enveloped in an atmosphere of liquor sanguinis, and that they are continually absorbing from it the materials required to maintain them in a normal state of health, it is easy to comprehend how a variation in the quality of this fluid necessarily disturbs the nutrition of the tissues, and, as a consequence, may diminish their vital capacity of resisting injury, and also of repairing it when incurred. In the language of the older surgeons, "a vitiated state of the blood is a very common cause of the ill behavior of wounds in regard to their kindly healing." Now, habitual excess of food and drink, and also habitual lack of proper food and deprivation of an adequate supply of pure fresh air, which prevents elimination of the products of textural waste, equally tend to impair the quality of the blood, and consequently of the tissues supplied by it; so that slight injuries, which in a state of health would take on prompt repair, under these unfavorable circumstances linger in healing, and run into suppuration, or into partial or molecular gangrene; at other times they become indolent, refuse to cicatrize, or remain indefinitely in the condition known as *chronic inflammation*. As common examples, taken from clinical observation, the following are cases in point:—

A man of middle age, of sedentary occupation, living too well, in apparently full health but perhaps slightly defective in complexion and flabby in muscle, in consequence of the slight violence caused by straining at stool, is taken with painful swelling in the ischio-rectal fossa, which results in an extensive abscess, followed by tardy and imperfect repair, and leading to chronic fistula in ano, or even to danger of death.

In another case a half-starved child is seized with a hard swelling in the thickness of the cheek, which in a few days turns black at its centre, and results in perforation, constituting the form of disease known as *noma*, or *gangrænopsis*.

The presence of a poison in the blood, whether this fluid is otherwise impoverished or not, may predispose to inflammation. This is seen in the peculiar behavior of lesions, not arising directly from the disease, in persons affected by *syphilis:* instead of healing in a healthy manner, they are liable to take on the aspect of syphilitic ulcers, and to require anti-syphilitic treatment for their cure. The condition of the blood in *diabetes mellitus* begets a well-marked predisposition to hyperæmia of the intestinal mucous membrane, and to eruptions of the skin. An *eczema* of the genitals may have proved obstinate under the use of ordinary remedies, but as soon as the presence of sugar is discovered in the urine and the patient is restricted to a diet of animal food, the local inflammation tends to get well. Blood of defective quality, especially when certain poisons are present in it, tends to stagnate in limited areas, probably through its lack of full power to stimulate the heart and bloodvessels. The local hyperæmia which results from this tendency often constitutes the first stage in the development of inflammation. Hence the frequency of serous effusions in uræmia. Da Costa and Longstreth[1] speak of an "outburst of inflammation of the serous membranes"—*e.g.* intense pericarditis, with pleural and peritoneal effusion—the result of altered blood in Bright's disease, the patient having suffered, also, from uræmic coma.

The occurrence of eczema in the *gouty* is directly provoked by the acrid qualities of the perspiration. It is remotely favored by the condition of the blood; and "the gouty irritability" of the membranes, which is, in other words, a state of nervous hyperæsthesia, is caused by the same condition of blood. In proof of this we may point to the marked relief to these symptoms which usually follows "a crisis" of gout, in which the blood has relieved itself of its impurities. Here is a typical example of what is usually spoken of as the influence of a diathesis in favoring the occurrence of inflammation; and it illustrates what is true of all the so-called diatheses, namely, that their influence, if it can be properly so styled, is recognized mainly in the accidents which result from the peculiar constitutional quality. Another example of the predisposing influence of a diathesis is to be found in the *meningitis* of early life, which is often excited by *tubercular* deposit in the vicinity of the bloodvessels of the pia mater; the so-called tubercular diathesis acting as a remote cause of the inflammation.

The influence of *a defective or deranged nervous supply* to parts is in some instances easily recognized as a remote cause of local inflammatory action. Certain inflammations of the skin, especially the herpetic eruptions, furnish illustrative examples of this influence. Thus Von Bærensprung has shown that *herpes zoster* is always coincident with alteration in the anatomical elements of the intervertebral ganglion situated upon the posterior or sensitive, root of the spinal nerves supplying the affected parts. This form of skin disease occurs also in regions supplied by the trifacial nerve, and is accompanied by local anæsthesia of the inflamed integument, and a tendency to local death. The development of a vesicle of herpes on the cornea has been followed by the

[1] American Journal of Medical Sciences, July, 1880.

formation of a slough. In a case in which the ganglion of Gasser was subsequently found bathed in pus, the whole eye shrank and collapsed. An eruption of herpes about the lips after a paroxysm of malarial fever, or as consequence of functional gastric disturbance, is a very common occurrence. The formation of abscess in the vicinity of a focus of inflammation, as of a diseased joint, when not the result of a secondary or infectious process, has been attributed to reflex nervous irritation. Hyperæmic congestion, with local evidences of altered nutrition, has been observed in parts of which the nerves have been wounded or divided. The rapidity with which *bed-sores* form on the sacrum after exhausting fevers and surgical lesions of the spinal cord causing paraplegia, is well known; and the occurrence of *cystitis* in such cases is a constant result. Bed-sores begin by intense hyperæmia of the integument, followed by vesicular eruption, or pustulation, so that the lesion is at first distinctly inflammatory; but it is usually complicated by local death of tissue.

The period of life has less influence than has usually been ascribed to it as a predisposing cause of inflammation. Examples are frequently cited in favor of this cause, which are not, in reality, inflammatory affections. The effects of malnutrition in infants, or of the senile atrophy or degeneration of tissue incident to age, have been attributed to inflammation. In *childhood*, the process of nutrition is in its period of greatest activity, and the condition of acute hyperæmia—the first step towards the inflammatory condition—occurs promptly from any exciting cause. Any interruption of nutrition is followed by exaggerated results in derangement of healthy condition. Fever occurs readily, and from slight causes of provocation. It is not rare to see a weak, puny infant with a tendency to pus formation from the most trifling causes; this is usually traceable to a defect in the quality of the blood, the result of inadequate nourishment, or to the effect of poisonous influences upon the tender organism, by which it is more likely to be affected than in after life. But when positive inflammation is provoked in early life, if its processes are rapid in their evolution, they are more likely to be limited to the constructive stage; and there is in the infantile organism a fund of vital energy available to resist and to repair injury which is very remarkable. Evidence of this is to be seen in the results of very early operations for hare-lip, and in operations for imperforate anus; and in the striking cures effected in infantile syphilis by the judicious use of mercury.

On the other hand, in the *aged*, affections peculiar to this period of life, often referred to as inflammatory, are really of a different nature: neither prostatic disease nor senile gangrene is due to inflammation. The former, like the uterine tumors of the other sex, is, for the most part, due to fibroid overgrowth, and the latter is a result of degeneration of the arterial coats. The catarrhal affections of age, such as cystitis and conjunctivitis, are truly inflammatory, and tend to pus production. They arise from weakness in worn-out tissues by which the power of resistance to exciting causes of inflammation is impaired. It is to be remarked that the power of repair, although somewhat slower in its manifestations, rarely fails through age alone. This is noticeable in the constancy with which a good immediate result is obtained after the removal of epitheliomatous cancers so common at this period of life.

In middle life, the greater degree of exposure to traumatism, to the influence of poisons, and to the consequences of excess, explains the greater frequency of inflammatory affections at this period. Here, also, are encountered the contingencies attending *pregnancy* and *lactation*, which so often tend to inflammatory phenomena, whether by traumatism, the poisons to which the puerperal state exposes the patient, or the peculiar and rapid changes to which the blood is liable in these conditions. It would be wrong to omit the curious

perturbations of the nerve force which also attend them. There is a remarkable tendency to pus formation developed in exceptional instances, *post partum*, which affects the joints by preference, and of which there is no satisfactory explanation.

Habit of body, etc.—It was formerly a common belief that stout and full-blooded persons were especially liable to inflammation; that they were in a "state of plethora"—a condition of morbid fulness of the bloodvessels, indicating necessity for depletion. But, unless habitually over-fed, there is no foundation for this opinion. Moderate polysarcia is a constitutional peculiarity of many persons who enjoy good health. The habitually ill-fed, and those who from any cause are below their normal weight, are more likely to do badly after a serious injury or a surgical operation, through the supervention of some of the unhealthy complications of constructive inflammation.

Parts which have been already the seat of inflammation are more likely to fall into that condition subsequently, from slight provocation, than tissues whose vessels have never been subjected to previous over-distension. In common phrase, "their vitality has been weakened." This is also true of parts which have been exposed to prolonged or extreme cold, or which have been frozen. The habitual congestion, the itching, and the proneness to vesication and ulceration so commonly observed in chilblains, illustrate this predisposing cause of inflammation. It is probable that in addition to impairment in quality of the vascular tissues in parts thus "weakened," their nerves have also suffered in a similar way.

Every organ whilst in active use receives more blood, and is, for the time, hyperæmic. *Habitual functional hyperæmia*, especially when associated with fatigue from prolonged or excessive use of an organ, is a not uncommon predisposing cause of inflammation. Thus, reading all night is liable to be followed by suppurative inflammation of one or more of the Meibomian follicles—the ordinary hordeolum, or sty; and if this excess be frequently repeated, the tissues of the eyeball itself are pretty certain to suffer from inflammation in some form, if exposed to an exciting cause.

A young gentleman fatigued and heated by active ball play seated himself to rest by an open window where he was exposed to a draught of cool air. The next morning the muscles of the shoulder and arm were the seat of excessive pain on the slightest motion, in consequence of the development of a condition of "subacute inflammation" of the muscular tissues.

In regard to the influence of *climate*, and of meteorological phenomena, in predisposing the organism to inflammation, certain facts have been observed. In tropical regions, inflammations of the eyes of a serious character are very common and prevalent. So, also, is dysentery; and abscess of the liver is a frequent occurrence. The latter affection is very rare in cold, or even in temperate climates. In the latitude of New York, the summer heats predispose to inflammations of the intestinal canal, especially in children, tending to culminate in ileo-colitis. In cold weather, the air passages are more prone to inflammatory affections, of which the most common is bronchitis. March winds, as was pointed out over two thousand years ago by Hippocrates, were, in the Morea, as they are with us, the frequent causes of acute phlegmasiæ—of tonsillitis, bronchitis, and conjunctivitis; evidently because they favor sudden chilling, and give rise to irritation by producing clouds of dust.

In our climate, the seasons of the year which have been found most favorable for surgical operations, as regards freedom from inflammatory complications, are the midsummer and autumnal months. This is explained by the

freer access of fresh air. In the comparatively severe cold of the winter, and the changeable weather of spring, it is more difficult to secure healthy conditions as to ventilation. Erysipelas occurs more frequently in the late winter and early spring months.

Exciting Causes of Inflammation.—Strictly speaking, there is but a solitary cause for inflammation, and that is *irritation* of the living tissues by something which is called an *irritant;* and this act constitutes, technically, an *injury.* But there is an endless variety of irritants which may be separately recognized and classified for study of their nature and mode of action, with the ultimate purpose of modifying their influence and controlling their injurious effects. This constitutes *etiology*, the practical value of which lies entirely in its bearing upon treatment. We have enumerated certain of the remote influences which tend to invite and favor the action of irritants in causing inflammation ; and we have next to examine more closely the nature and qualities of the more immediately exciting causes of the inflammatory movement, so that we may be able to intelligently aid and favor it, as far as it is reparative or constructive, or to avert or control any of the destructive phases which it is liable to assume.

The *proximate* or *determining* causes of inflammation, more commonly spoken of as exciting causes, may act upon the body from without, as when a bullet strikes it; or they may take their origin within the body, as in epididymitis from tubercular deposit, or eczema from diabetes. This subdivision of the causes of inflammation, which has been already mentioned, is followed by the French school. The *external* causes are more obvious and easily recognized; the *internal* more obscure, and these cases are likely to be regarded as "spontaneous" or "idiopathic." It may be inferred from what has been already stated concerning the inflammatory predisposition, that the latter is more commonly present in connection with internal causes, for in them the pre-existence of some morbid condition of the organism is almost necessarily assumed. External causes of inflammation are for the most part either *traumatic* or (to adopt a parity in nomenclature) *toxic* in their nature, the locality in which the inflammation develops itself being determined more or less entirely by chance. Internal causes, on the other hand, are not only aided or invited by some predisposition on the part of the organism, but the part or organ in which the inflammation locates itself is in most instances also determined by it.

Cold and Sudden Chilling as Causes of Inflammation.—There is a frequent cause of inflammation which cannot be strictly included under either of these heads—cold or chilling—as applied to the whole body, or to a part. The ordinary hyperæmic and catarrhal symptoms which so commonly follow chilling of the body, especially of the feet, are familiar to all. They are caused by sudden changes in the constitution of the blood from the temporary arrest of function of the skin as an emunctory, whereby certain effete and presumably noxious materials which should be eliminated are retained and act as blood-poisons. In this manner a species of temporary intoxication is produced. The resulting inflammation is not usually of a serious character, and shows a certain preference for the air-passages, although it may affect any part of the body—especially a part that has been previously weakened. A general chilling varies greatly in the degree of gravity of its effects; it may involve any internal organ of the body, and to such an extent as to prove mortal.

A gentleman of 28, in full health, stripped himself entirely on returning home from business, on an exceptionally hot day, and threw himself on a lounge before an open

window to cool off before dressing for dinner. He fell asleep, heedless of a thunderstorm accompanied by a decided fall in the temperature, and awoke thoroughly chilled. On the same night he was seized with a rigor which proved to be the initial symptom of an acute general peritonitis, which terminated fatally within the week.

Severe chilling of a part is also a frequent cause of inflammation. What is known in England as "railway paralysis" is the result of inflammation of the facial nerve, or its neurilemma, from sitting in the draught of an open window when the cars are in rapid motion.

A gentleman had a severe inflammation of the epididymis and testis which led to complete atrophy of the organ. It followed a chilling of the testicle from sitting for an hour upon a cold stone doorstep, in thin clothing, after being heated in walking. The pendulous organ rested upon the cold seat and had become sensibly chilled, as he noticed at the time. The next morning it was painful and swollen. The inflammation subsided in a week, but continuous shrinkage in volume of the organ followed. There was no urethral lesion.

Inflammatio a frigore, as the ancients called it, has always been regarded, popularly as well as professionally, as a very common occurrence—cold being universally received as a sufficient and satisfactory cause of the inflammation. It is not improbable that mortal injury, or actual necrosis, of some of the anatomical elements of a chilled organ may set in action the series of changes which, according to our view of its pathology, constitute inflammation; the blighted elements may degenerate, or liquefy, and undergo absorption; or the inflammation which their presence has excited may culminate in abscess, and thus effect their expulsion from the organism.

Reverting to the classification of causes which have been recognized as competent to excite the inflammatory process, we shall proceed to examine in detail the most typical of them.

Incised Wounds.—There is no form of mechanical violence that excites inflammation, in which the process is developed more uniformly in its benign or constructive form than in division of the tissues with a sharp knife so as to produce an "incised wound," such, in fact, as that made by the surgeon in cutting operations. And yet a scalpel with the keenest edge cuts on the principle of the saw, and invariably leaves in the wound myriads of microscopic particles of lacerated tissue. These are carried away in part by the flow of blood and the subsequent liquid exudation, and the rest undergo liquefaction and absorption by the lymphatics. They do not apparently interfere with the kindly succession of changes which, when the cut surfaces are quietly retained in proper apposition, bring about prompt union "by the first intention." These changes are exudation, cell-proliferation, the generation of new capillaries which inosculate across the breach of continuity, and the organization of a film of cicatricial tissue, often hardly visible, by which Nature's "first intention" is completed. This happy phrase by which Hunter described the phenomenon of "primary union," was applied to a result accomplished by what he called "adhesive inflammation." The discovery of the microscopic mechanism of this process has not impaired in any degree the aptness of the phraseology of the great observer. It is for us to notice that, in its most perfect results, our senses detect, in the process of primary union, neither pain, heat, redness, nor swelling; simply the healing of a textural breach by a nutritive act, effected without excitement, and by an apparently competent mechanism. Whilst admiring the perfection of this typical expression of the reparative act, our part is to detect, if possible, the causes which lead to such frequent deviations from its simple effectiveness, and, if possible, to prevent obstacles to its uniform accomplishment. The sources of

injury next to be considered—stabs and punctured wounds—often present features and complications by which a result so desirable as that just described is prevented.

Punctured Wounds.—Puncture by a smooth polished instrument resembles an incision, and, if the track of the wound be kept at rest, and subjected to gentle pressure in order to keep the divided surfaces in contact, it generally heals kindly. Wounds made by surgical needles for suture, exploration, or aspiration, are examples; even trocar wounds heal promptly. Thus, when the tissues are simply divided and thrust aside, there is no cause for complications; but from a puncture made by a rough instrument, as where a rusty nail perforates the sole, larger particles of tissue are liable to be killed, and foreign matter is apt to be left in the wound.

The presence in a wound of foreign material is a very common source of interference with the healthy process of repair. Hence the formal rule enjoining its careful removal before dressings are applied. In the first place, it prevents accurate contact of divided parts, a condition absolutely necessary for prompt healing. In the second place, the presence of a foreign body in contact with the living tissues, as a rule, acts as an irritant, and ushers in a series of phenomena which have for their purpose its expulsion from the organism. These are, afflux of blood to its vicinity, the germination of embryonic cells, their accumulation in the form of pus, and ulceration in the direction of the nearest free surface, by which a free vent is gained, and the foreign substance is thus thrown off. These phenomena are attended by pain, heat, redness, and swelling, and they constitute a phase of inflammation which attains a degree of intensity that involves destruction of tissue. This forms at once a contrast with the simple process of repair. There are exceptions to the rule that foreign bodies act as irritants, and provoke suppurative inflammation. Some of the metals, such as lead, silver, and iron, are in a certain degree tolerated by the tissues, causing only a grade of inflammation which ends in tissue formation, and they become finally enveloped by a sac of connective substance called technically a cyst; they are said to be encysted. But these exceptions serve only to prove a rule. This is exemplified by what Furbringer, of Jena, says of hypodermic injections of metallic mercury: that "they are well borne, but within twenty-four hours inflammatory symptoms set in, and frequently result in abscess."

Our own tissues, when from any cause deprived of life, become foreign bodies and constitute the most common examples of irritants, even when the dead masses are quite minute. The ordinary boil is due to this cause, which may be demonstrated by examining its core microscopically. The core of a boil consists of a little slough of connective substance, mainly of the yellow elastic fibres, containing in its meshes some leucocytes or pus cells. This small mass has become necrosed, and its white fibrous element has liquefied and mingled wi.h the pus; but its yellow fibres, one of the most indestructible of all the simple tissues, remain unchanged and constitute the foreign body the presence of which has excited the suppurative inflammation. Necrosis of connective substance in minute masses is not a rare occurrence. It is due to some defect in nutritive quality of the blood, or of the nervous supply transmitted to the tissues. Its cause is obviously central, and not local; for boils often occur in indefinite succession in different localities; and their tendency to recurrence is distinctly controlled by the internal use of certain drugs which modify favorably the blood and the nerve force, such as arsenic, sulphide of calcium, and the hypophosphites. Certain *blood poisons* give rise to disseminated tissue necroses. In smallpox, each pustule is evolved for the

expulsion of a disk of dead true skin. Hence the depressed cicatrices or "pits" which these minute abscesses leave behind them. The death of a portion of *osseous tissue*, from scrofulous malnutrition, or from a traumatism, as when a scale of bone, giving attachment to a muscle, is torn off in some violent effort, or, in fact, necrosis from any cause, is a common source of origin of deep abscess.

Foreign substances liable to provoke inflammation by lodging in the body include bullets, cloth, splinters of bone, of wood, and all the materials liable to be associated with gunshot projectiles and explosive compounds of every variety; and, with the exceptions mentioned, the inflammation provoked by them is attended by suppuration. Gunshot-wounds are, in a certain sense, rough punctures.

In considering lesions of bone by mechanical force, in their relation to inflammation, we encounter at once a remarkable clinical feature—not, indeed, peculiar to this tissue, but typically illustrated by its behavior under injury. In a large proportion of lesions of bone, simple fractures, for example, the inflammatory condition is limited entirely to its constructive phenomena, very rarely transcending the boundaries of the process of repair. On the other hand, in a comparatively small proportion of them—the compound fractures—the inflammation often assumes its most destructive aspects; and these constitute a grave and critical class of surgical cases. In the former, uncomplicated and satisfactory repair is the usual result; in the latter, there is frequently loss of limb and loss of life. Formerly it was held that the additional violence inflicted on the soft parts accounted for the difference in the amount and character of the inflammation occurring in compound fractures; this complication being regarded as a sufficient explanation of their increased gravity. But we have gradually learned from clinical experience, largely from the success of Stromeyer's operations upon tendons and fasciæ—in which these parts were cut across by a small knife inserted through a minute wound which was promptly closed and sealed—that the subcutaneous character of the lesion affords the true explanation of the greater safety in simple fracture, and that exposure of the injured parts to the air is the source of danger in compound fracture. Surgical operations for the relief of deformities, as previously practised, had proved so dangerous that they were rarely resorted to, until the German surgeon demonstrated that the method just described was uniformly safe. It has become a received doctrine in surgery that, not only in fracture, but in any lesion whatever, when the external air is excluded, the phenomena of inflammation that follow are restricted to those of the benign or constructive order.

The explanation of this interesting fact, that subcutaneous lesions are uniformly repaired by constructive inflammation, the discovery of which has added vastly to the safety and utility of operative surgery, has been sought for in various directions. Addison ascribed it to the uniformity and to the elevation of the temperature at which the injured parts were preserved during the subcutaneous process of healing. He recognized the close resemblance between the vital phenomena of reparative inflammation and those of embryonic development, as studied in the egg of the chick during incubation, and correctly inferred that the conditions which nature always secured for the latter (in warm-blooded animals) would be most favorable to the process of repair; and that liability to frequent chilling would be as harmful to the progress of healing as it was in the process of incubation.

More recently Lister is seeking to demonstrate that the apparently noxious influence ascribed to the air is not due to any intrinsic qualities of the air, but to the presence in it, under almost all conceivable circumstances, of microscopic germs of micro-organisms. He asserts, in accordance with Pasteur's

demonstration of their habits, as ascertained by their cultivation in different media, that these organisms find in the raw and exposed surfaces of our tissues avenues of entrance, and that they at once encounter materials which constitute a suitable pabulum for their germination and development. The presence, in the soft vital materials of a recent wound, of myriads of micro-organisms multiplying, at their expense, with the inconceivable rapidity of cryptogamic fungi, accomplishes the destruction of their vital and chemical properties, and entirely unfits them for use in the process of repair. Reparative inflammation fails, therefore, for want of material, and is replaced by the condition which constitutes destructive inflammation. Pasteur's discovery of the fermentative nature of putrefaction, and his proofs of the production of this process by the struggle for life of minute organisms like the *torula* of the yeast plant, lends verisimilitude to the doctrines advocated by Lister. At the present time they afford the most probable explanation of the habitually more favorable results, as to healing, of wounds excluded from contact with the air, and of the greater mortality of compound fractures as heretofore treated. The evidence upon which this conclusion is based is derived from clinical observation of the more favorable results obtained by treating compound fractures in accordance with the antiseptic method, which aims to destroy or exclude all microscopic aerial germs.

The germ theory of disease, and its bearing upon inflammation, is a subject which presents a degree of importance at the present time, to which it is difficult to place a limit. No study of the exciting causes of inflammation can approach completeness without a full consideration of its claims to credence, and a due estimate of their value. It will be necessarily discussed hereafter in connection with the *toxic* exciting causes of inflammation.

Mechanical violence that results in wrenching, straining, dislocation of joints, affecting principally the white fibrous tissues composing the ligaments, and the tendons with their sheaths, produces, for the most part, lesions not exposed to contact of the air. The inflammation that follows is, therefore, rarely otherwise than simply reparative. Compound dislocations, however, present most of the unfavorable features of compound fractures.

Contusion of living tissues involves not only a possible breach of continuity, but also, to a variable extent, entire or partial destruction of textural life. In every contused wound of any severity, there are liable to be sloughs, or parts entirely killed, which must be separated, or thrown off, by a vital process before final healing can take place. There are, also, parts often described as half-killed, that is, so far injured as to render their survival a matter of doubt —certainly, of delay. This complex condition includes several exciting causes of inflammation besides the general stimulus to repair that follows every injury. To this stimulus the tissues which have been simply divided, but not otherwise seriously damaged, are alone in a condition to respond. Hence the rule, in dressing contused wounds—to bring the surfaces together as for primary union, but with very moderate retentive force, in order to test the capacity of the doubtfully injured portions to undergo the changes which accompany constructive inflammation, and to secure any advantage that may be attainable.

Of the parts in a contused wound which have been damaged, but not entirely killed, a portion may recover and participate in the healing; whilst the rest, sooner or later, die. The delay required to determine the fate of the doubtful parts renders suppuration, under ordinary dressings, unavoidable. The process of separation of dead from living parts, under ordinary circumstances, has heretofore rendered granulation and suppuration inevitable.

The presence of dead tissue in a wound, before a granulating surface has become organized, involves a certain danger of septic poisoning. The necessary occurrence of these several sources of irritation in a contused wound, as consequences of its nature and mode of production, explains the greater liability to inflammatory complications of this form of surgical injury. In lesions of the internal viscera from mechanical violence, when they are of moderate extent and do not implicate large bloodvessels, it is probable that healing often takes place without any recognition, or even suspicion, of the existence of such a lesion—the uniform high temperature of the injured part favoring prompt repair, as in a subcutaneous wound. This is rendered probable by the discovery of recent cicatrices in the lungs, liver, and kidneys in patients who have died from the later consequences of coexisting external injuries.

It is evident, from this brief survey of the exciting causes of inflammation arising from mechanical violence, that, as far as we can learn from clinical observation, these causes act primarily, and, in fact, mainly, by stimulating the process of repair. Deviations from the simple constructive process which may manifest themselves subsequently, in the progress of a case, are explained: first, by the conditions peculiar to the injury, *e. g.*, the necessity for getting rid of matters foreign to the economy in order to accomplish healing, and by other causes of delay in the process; secondly, by the accidental interference of noxious agents which, by acting directly upon a wound, impair the quality of the materials furnished by the organism for healing it.

The *presence of a clot of blood* of any size in a wound has always been regarded as a possible cause of at least partial failure of union, and of pus formation. Thus, bleeding in a stump after the ordinary mode of dressing, in consequence of failure to secure a vessel which has bled after reaction, or from inadvertent bruising, or injudicious pressure, has often been the cause of prolonged heat and pain, and of fever protracted beyond the usual limit, and finally of suppuration, abscess, and sinus. To prevent repetition it may be stated here, that this very frequent cause of inflammation which, combined with the presence in the wound of ordinary ligatures of silk, has been, heretofore, one of the most common causes of ill behavior in wounds, has been found by recent clinical experience to be preventible by the use of antiseptic dressings and ligatures of prepared catgut. When these precautions have been carefully employed, clots even of considerable size have been observed to shrink and lose their color, and to become organized by the appearance in their substance of embryonic cells and newly-formed capillaries, and to assist directly in forming a bond of union. The prevention of putrefaction by the antiseptic method, a result which can always be commanded, apparently favors the more perfect accomplishment of the constructive process. In recent experiments on animals, masses of living, and even of dead (but not putrid) tissue, have been successfully included in the peritoneal cavity, and have become organized.[1]

[1] A paper was presented at the Berlin Medical Congress of April, 1880, by Dr. A. Rosenberger, of Würzburg (*Archiv für klinische Chirurgie*), on this subject. Having observed that foreign bodies and ligatured portions of tissue, *e. g.*, the returned pedicle after ovariotomy, etc., caused no trouble, as a rule, in operations conducted antiseptically, Dr. R. introduced pieces of living muscle, and even whole kidneys, with antiseptic precautions, into the serous cavities of animals without any, or with only the very slightest, reaction. After a time the pieces of living tissue disappear without leaving a trace. The tissue need not be from the same animal, or even from the same species of animal. The process seems to be, at first, one of encapsulation. From the capsule cells wander into the inclosed tissue and break it up. The capsule receives a capillary network from its surroundings, and the foreign tissue thus nourished, if it come from an animal of the same species, may continue to live on. In certain cases of partial failure, amongst those in whom masses of dead tissue previously soaked for many days in alcohol had been introduced, a pus cavity was found in the centre of the foreign mass, which had become permeated by leucocytes and by new capillary loops. (Medical News and Abstract, May, 1881.)

It is a circumstance of daily observation that a slighter degree of mechanical disturbance than any of the sources of injury heretofore described, not amounting to violence, but more or less persistent in character, is capable of begetting a condition of local hyperæmia, and, if continued, of exciting positive inflammation. This is exemplified by the friction of the skin by articles of clothing; and by the action of cold winds upon the surface. The normal motions of a joint are competent to excite inflammation of a higher grade in a trifling lesion in process of healing, seated, perhaps, on its dorsal aspect, as for example an abrasion of a knuckle—which is so likely to fester. In other words, the simple process of repair whilst in kindly progress, is, by this form of excitation, liable to be irritated to the point of suppuration.

A blacksmith received a kick from a horse upon the knee. After a few days' rest, as the contusion had ceased to be painful, he resumed his work. But pain about the knee soon returned, and some days later he was brought to the New York Hospital with much fever and an acute fluctuating swelling around the joint, simulating inflammation of the joint itself. After evacuation of the abscess, the case did well. The patient, who was addicted to beer, and thus predisposed to suppurative inflammation, explained in regard to his condition that he had been doing perfectly well after the accident, but, on returning to his work, "he must have taken cold, and then inflammation set in." The true explanation of the occurrence of destructive symptoms in this case was the irritation inflicted upon parts undergoing the process of repair by too early resumption of the use of the joint. By this exciting cause the constructive grade of inflammation was disturbed in its progress, and converted into suppurative inflammation.

Slight but persistent mechanical action must therefore be recognized as one of the exciting causes of inflammation. It is a frequent cause of interruption and of complication of the healing process, and its power of doing harm is very commonly underestimated. Its bearing upon the great value of *quiescence* as a remedial agent in inflammation will be hereafter considered.

The action of a chemical irritant in exciting inflammation is illustrated by the phenomena which follow the application of a drop of nitric acid to the surface of the skin. Within a minute or two, an increased redness is perceptible immediately surrounding the drop of acid. This area of redness steadily extends, growing more intense in color, until it attains a diameter of two or three inches. At the same time there is a slight increase of fulness and heat in the part. Within the hour, these symptoms may have disappeared. The redness, due to acute hyperæmia, has passed away, as have all the symptoms except a scarcely perceptible circle bounding the margin of the yellow-tinted eschar produced by the action of the acid upon the epidermis and the true skin—which latter is involved to a depth measured by the strength of the acid. After a day or two even this narrow circle of redness vanishes, and at the end of a fortnight the yellow eschar, which has become somewhat darker in color, becomes detached, disclosing a smooth cicatrix, of a positively red color, invested with epidermis. These phenomena represent, typically, the behavior of most chemical irritants as excitants of inflammation. Their action is limited to that of a simple stimulus to repair; and, when severe enough to produce death of tissue, the sloughs are thrown off without suppuration, provided that the air has been excluded, or that antiseptic dressings have been employed. Burns by phosphorus would seem to constitute an exception, as the acid generated by the combustion of the phosphorus acts as an additional irritant to the raw surface.

Heat produces results similar to those of the potential cautery, but in greater variety. It may cause a simple blush of transient hyperæmia, or vesication,

or death of tissue—superficial, or deep. The inflammation following simple burns, or scalds, if no eschars have been formed, is limited to simple repair, especially if the air is excluded from the seat of injury. When there is death of tissue, the separation of the eschars, as a rule, involves suppuration. Repair by the second intention, that is, by granulation and suppuration, often fails, in extensive burns, through lack of cicatricial power, and from other causes; but, if we except pyæmia during suppuration, inflammation, as such, rarely leads to a fatal result in burns.

There is an opinion prevalent amongst practical surgeons that the unhealthy forms of inflammation are less likely to follow in wounds to which the actual cautery has been applied, or where incisions have been made by the incandescent knife. It is also a common belief that healthy reparative inflammation is promoted by the application of the caustic acids and alkalies. This is probably founded, at least in a measure, upon their efficiency in destroying poisoned surfaces, *e. g.*, venereal and phagedænic ulcers, and parts attacked by hospital gangrene. Of the escharotics in vogue of late, the chloride of zinc enjoys much reputation through its reputed antiseptic quality; and there is evidence that the liberal application of an eight per cent. solution, which is decidedly escharotic, to a recent wound, does not interfere with its subsequent union by the first intention—certainly under antiseptic dressing.

The mode which we have adopted of studying inflammation, by scrutinizing the causes which have been proved to be capable of producing this condition in our tissues, and the manner in which these causes act, has led, thus far, to the recognition of two well-marked grades of the inflammatory process. One of these is the simple form of repair which constitutes Hunter's union by the first intention; the other is the process of healing by the second intention, or by suppuration and granulation. It has also been recognized that tissues which have been damaged by injury sometimes die in the effort at repair, and apparently in consequence of it. The exciting causes which next present themselves for examination, namely, *the sources of poisonous infection*, are more various in their nature, and also, in some of their forms, more obscure in their mode of action than those heretofore under consideration. Although the existence and the noxious influence of some of these sources of injury has long been suspected, they have, until recently, escaped general recognition. The effects of the inflammation-producing poisonous agents upon the organism cover a wider range than those exciting causes which act only mechanically, or chemically. In addition to their action upon the tissues generally, some of these poisons exert a specially noxious influence directly upon the nervous centres. Many of them possess, also, the peculiar power of perpetuating their poisonous influence, after their introduction into the organism, by a process allied in its nature to that which causes fermentation.

The poisonous agents capable of producing inflammation fall naturally into several distinct classes, according to their origin and nature: (1) the mineral poisons; (2) those elaborated by the vital chemistry of plants; (3) the poisonous secretions of animals; (4) the poisonous infection arising from the action of microscopic cryptogamic parasites; and (5) putrid substances.

The Poisonous Action of Certain Minerals—arsenic and mercury, for example—gives rise to inflammation in a manner quite different from the chemical irritation produced by the primary contact of these metals, or their salts, with the living tissues. The peculiar nature of the inflammation is generally conveyed by the use of the term specific, and its action is only developed after the mineral poison has entered the blood-current and is circulating, to all ap-

pearance, harmlessly in it, when, as soon as the ingestion of a certain amount has been reached, an active gastric hyperæmia attended by vomiting supervenes, if the poison be arsenic, or an inflammation of the mouth attended by salivation, if the poison be mercurial. These inflammatory phenomena may be produced with equal certainty if the poisonous substances are introduced into the blood-current through the skin, or through the mucous membrane of the rectum, which may be done without necessarily producing any inflammation of either absorbing surface; so that there is no question of local chemical irritation from direct contact. The poisonous action upon the stomach, or the mouth, is something different from that produced by a chemical irritant, and it is effected by a different mechanism; it is "specific." The tissues of the stomach, or of the mouth, are, for reasons unknown to us, more sensitive to the action of these mineral poisons than the tissues of other organs; and this poisonous action manifests itself by producing the phenomena of inflammation. The renal congestion and hæmaturia which result from persistent inhalation of volatilized turpentine is readily explained by the irritating action of this substance upon the tissues of the kidney during its elimination from the blood, and the same mechanism has been supposed to explain the desquamative nephritis that follows scarlatina, and the follicular intestinal ulceration of typhoid fever. But neither arsenical gastritis, nor mercurial stomatitis, has been accounted for in this way; and the preferences of these mineral poisons for certain particular organs must be regarded, for the present, as ultimate facts. But they are not facts without parallel, for it will be found hereafter that certain septic poisons, when they gain access to the blood, give rise to congestion and inflammation of serous membranes, and at certain preferred localities of the intestinal mucous tract.

Poisonous Action of Plants.—The effect of the contact of the "stinging" nettle (Urtica), in producing a papular eruption, of the poison vine (Rhus), in causing a vesicular irritation of the skin, of croton oil, in bringing out a crop of minute abscesses, are familiar examples of inflammation resulting from the simple contact of substances of vegetable origin. A search for the explanation of these phenomena leads us also to the ultimate fact that these substances are in some way hostile to textural life or well-being, and that their contact, probably through some injurious influence exerted upon the nerves of the locality, temporarily perverts or arrests the nutritive process.

Poisonous Secretions of Animals.—Under the third class—of poisonous secretions elaborated in the living animal body—we have positive clinical evidence that inflammatory action may be directly excited by the contact of pus, or of other products of pre-existing inflammation, that is of simple, non-specific inflammation, in the products of which there is no suspicion of the presence of extraneous poisonous matter derived from any other source. The contagious quality of so-called healthy pus, taking this secretion as a typical product of inflammation, is, at the present day, so generally admitted to exist, within certain limits, that we may dispense with a formal demonstration of the fact. The evidence collected by Simon, who contended for its existence in 1860,[1] showing that in examples of inflammation attributed to *sympathy*, the inflammation is in reality due to the contagious quality of pus; and the more recent researches of Chauveau[2] and others, leave nothing to be desired in the way of confirmation of the fact. As to the nature and quality of the inflammation

[1] Holmes's System of Surgery, 1st ed., 1860, vol. i. p. 68; id. op. 2d ed. 1870, vol. i. p. 46.

[2] Revue des Cours Scientifiques, 2e serie, 1re année, 14 et 21 Octobre, 1871; 2e année, 13, 20, et 27 Juillet, 1872.

thus incited, we will speak farther under the head of "varieties" of inflammation; but it is as well to remark here that although the subcutaneous injection of pus in the lower animals is capable of inducing febrile action of the simple inflammatory type, with great certainty, the fever thus produced, as a rule, subsides spontaneously; and the local inflammations excited by the contact of inflammatory products, when the latter are fresh and unmixed with other sources of poison, are, for the most part, of the simple catarrhal variety, and neither unhealthy nor destructive.[1] The practice of inoculating *pannus* of the conjunctiva and cornea with fresh pus to provoke inflammation for a curative purpose, employed on a large scale in Germany, illustrates at the same time the contagiousness of fresh healthy pus, and the comparative harmlessness, in a general way, of the inflammation thus excited.

The poisonous qualities of certain living insects, not to speak of dead insects such as cantharides, find their most common examples in the mosquito, the bee, the wasp, etc. The introduction of the poison of the *mosquito* into the substance of the skin of a person who has not acquired an immunity from its action, is followed within a few minutes by all the cardinal symptoms of inflammation in miniature. The pain takes the form of itching; the redness forms a well-marked areola produced by the afflux of blood from every direction towards the point of puncture—with an appreciable increase of local heat; and the swelling, from rapid exudation, is often so tensive as to arrest the capillary circulation at the centre of the affected area by its pressure, causing a distinctly pallid spot, or wheal, at its apex. After a short time all these symptoms disappear, leaving a point of ecchymosis, recognizable with difficulty on account of its minuteness. This gradual and entire disappearance of the symptoms of inflammation affords an example of the phenomenon generally described as "*delitescence*" or "*resolution.*" Not unfrequently a little thickening of the tissues remains at the seat of the injury just described, and, from time to time, a slighter degree of itching may recur. In persons of an irritable habit an ulcer may possibly be established by the repeated scratching thus provoked. There is, in fact, a certain amount of persistent impairment or degradation of vital quality incurred by the nerves and other textural constituents of a part by the contact of an animal poison—which is a noteworthy characteristic of this form of injury. The apparent reluctance to heal, and the tendency to ulceration, manifested in some cases after *vaccination*, is an example of the effects of local tissue poisoning; and the same phenomena are still more frequently noticeable in the behavior of the contagious venereal ulcer usually called "*chancroid.*" Thus the lesson is to be learned from so trifling a poisoned wound as a "mosquito bite," that a poison is a noxious agent capable not only of directly exciting the condition of inflammation in our tissues, to a degree of intensity apparently out of all proportion to the injury as regards its magnitude or gravity, but, also, of leaving after it a more or less permanently damaging effect upon those tissues, by which their vital quality is invalidated.

In addition to the general conclusion that this source of injury is competent to cause a local derangement of the nutritive machinery, which manifests itself by the phenomena of inflammation, it may be remarked that this development of the inflammatory condition has, apparently, no reparative purpose. It is an extravagant outbreak, on a limited scale, of excessive action on the part of the local nutritive apparatus, by which, as far as we can see, no object is

[1] Simon concludes "that the contagiousness of communicable inflammation seems to be in some special way relative to corpuscular development, and the contagium to be inherent in growing forms; whereas, the contagiousness of the specific inflammation seems rather relative to their destructive acts, and the contagium to reside in defunct and dissolving organic compounds." (Loc. cit. ed. 1870, p. 51.)

to be attained. Heretofore, the inflammatory changes provoked by the exciting causes which have been under consideration, have had an unmistakable purpose, namely, of healing a breach of continuity, or of getting rid of a foreign body; and when this purpose was attained, the abnormally excited nutritive action subsided. But in the examples of inflammation provoked by poisonous contact or influence, there has been no such object discernible—either reparative or eliminative—as far as we have evidence. The honey bee, we are told by Huber, often leaves his serrated weapon in the little wound through which the poison has been injected in the act of stinging; and here a foreign body is to be got rid of; but there is no such cause for eliminative inflammation apparent in the "mosquito bite." We may adopt the additional conclusion, therefore, that a poison, as an excitor of inflammation, possesses a novel injurious quality as regards the tissues—something superadded to the cutting, crushing, or burning of the mechanical and chemical lesions—the essential nature of which eludes our grasp. We are compelled to characterize this noxious quality by its effects upon the nerves and bloodvessels of a part, and we therefore speak of the part as *poisoned*.

The poisoned condition is a local manifestation of the same nature as the more general influence upon the nervous centres already attributed to this class of injurious agents. Prof. Agnew gives an example of this poisonous influence in a case in which it followed a wound inflicted by a *centipede*, a poisonous myriapod common in warmer regions, "sometimes brought to Eastern cities concealed in hogsheads of sugar. I have seen," says he, "a stevedore suffer for weeks from violent local and constitutional symptoms in consequence of a sting received on the hand while handling one of these hogsheads on the wharf. The fingers remained purple, and the hand and arm weak, for a long time. His general health was seriously impaired by the injury; and when I last saw him he looked like a man who had passed through a tedious and wasting spell of sickness."[1] Within the experience of the writer, a naval officer stung by one of these insects on the hip, was subject for a number of years to an annual eruption of angry papules at the seat of the poisoned wound.

The influence of the poisoned condition upon the grade of inflammation developed in tissues thus affected should not be overlooked. For the nerves and capillaries of parts thus degraded in the quality of their vitality, as we have already shown in the examples of delayed healing after vaccination, and the sloughing of certain venereal ulcers, do not respond in a healthy manner to the stimulus to repair. Such poisoned tissues manifest a distinct tendency to suppuration, and to molecular disintegration.

Effects upon the living tissues somewhat similar, but far more serious in degree, are produced by the venom of the *poisonous serpents*. The more active of these poisons, when introduced into the circulation, cause death quite promptly by the direct action of the venom upon the nervous centres and the heart. Singularly enough, the full noxious influence of serpent venom, as the researches of Weir Mitchell have shown, is transitory. Like the effects of the woorara, it tends to decline, and, after a certain interval, to disappear.[2]

In the cases in which its immediate mortal effect has been escaped, the local influence of serpent poison upon the tissues is that of an inflammation-producing agent of great power. The local symptoms following the bite of a rattlesnake are intense pain, with rapid swelling attended by surface discoloration and mottling. Incisions of the affected part give issue to serum, colored

[1] Principles and Practice of Surgery, vol. i. p. 227. Philadelphia, 1878.

[2] Researches upon the Venom of the Rattlesnake; with an investigation of the Anatomy and Physiology of the organs concerned. Published by the Smithsonian Institution. Washington, 1860.

by blood; the physiological condition of the vascular walls, and also of the blood itself, is manifestly altered by the immediate contact of the poison, the blood giving early evidences of putridity. There is a strong tendency to local gangrene. When this form of danger is escaped—wholly, or partially—suppuration in the connective tissue follows. This suppuration is diffuse in its character, that is, it tends to travel along the planes of connective tissue, as in phlegmonous erysipelas, without limitation by organizing barriers of granulation tissue, the poisoned condition of the tissues preventing their formation. At a later period, when these barriers form, it becomes evident that the intensity of the inflammation-producing action of the venom has become less, and that the reparative grade of inflammation has established itself in place of the destructive; in other words, that the vital nutritive process is no longer overpowered by the influence of the poison, and is again working normally. In a case of rattlesnake bite (by an imported snake), reported by Sir Everard Home, the victim, having escaped the earlier effects of the poison, died exhausted by suppuration in the third week.

This clinical evidence shows that there are exciting causes capable of giving rise to the inflammatory condition in its most destructive phases—causes more intense and effective than any heretofore examined. These latter, indeed, might have been regarded as exaggerated examples of a stimulus to repair, demanding, simply, an increased effort in nutritive activity. The former, on the other hand, exert a directly damaging effect upon the apparatus of nutrition itself, threatening extinction of textural life; and it is only after this first influence has been recovered from, mainly in consequence of the evanescent quality of the noxious agent, that the reparative act comes in play.

What it interests us especially to learn concerning inflammation, is, whether there is any essentially destructive quality that belongs intrinsically to the condition; or if its destructive phases are always traceable to the influences by which it has been excited. This question is important in view of its direct bearing upon the practical subject of treatment. If the nature of its exciting cause determines in any degree the grade of the inflammation, we cannot study the nature and mode of action of exciting causes too closely. More light may be thrown upon this question by observing the several modes in which inflammation is produced by the sources of poisonous injury yet awaiting consideration.

The grosser *parasites*, mainly of an animal nature, such as acari, trichinæ, echinococci, lice (as in the disease known as phtheiriasis), and intestinal worms, produce various injurious effects upon our tissues and organs, but they excite inflammation only incidentally as foreign bodies. They are mentioned in this connection as suggestive of the liability of our bodies to parasitic invasion. It is the mode of action of the multiform *microscopic fungi*, and their germs, that affords most interest to the surgeon, because there is reason to believe that these invisible particles of organized matter are competent to act injuriously by direct contact with the tissues when exposed in wounds.

The germs of the *vibrio septica*—one of the most active and dangerous of the bacteria, according to Pasteur—are singularly indestructible by extremes of heat and cold, and by most of the powerful chemical agents; but the organisms into which they develop, under favorable circumstances, are not so tenacious of life; they have the peculiarity of not being viable when exposed to the influence of free oxygen. Wherever oxygen has no access, they germinate, however, with inconceivable rapidity, supporting life by appropriating from the animal materials by which they are surrounded—wound-fluids and granulating surfaces, for example—the sustenance they require. In the changes, chemical and vital, to which these animal materials are subjected in the struggle for existence of the vibrios, the result is putre-

faction. The presence of the *vibrio septica* begets putrefaction in a medium of animal matter by inducing a process of fermentation.

It is asserted that the vibrios evolved from the germs first deposited upon the surface of a wound, die from exposure to the oxygen of the air, and afford a protection to the surviving germs beneath, which are thus enabled to germinate indefinitely. In the chemico-vital changes incident to the process of putrefactive fermentation thus begotten, certain poisonous combinations are formed. These are designated as *septic poisons*, and they are regarded as the source of the dangerous diseases which take their origin in wounds. The wound diseases thus produced comprise all the unhealthy and destructive forms of local wound inflammations, as well as the consequences of the absorption of septic poisons into the general circulation, namely, septicæmia and pyæmia. This micro-organism, the *vibrio septica*, is considered to act as a poison, first, by spoiling the materials provided for repair, and thus interrupting the constructive process in a wound; and, second, by acting as a putrefactive ferment and elaborating septic poisons which cause the subsequent destructive phenomena.

These are the facts which Pasteur asserts that he has demonstrated, and upon them, mainly, Lister has based his antiseptic method of treatment for wounds, believing that they afford an adequate explanation of the mechanism by which destructive inflammation is caused by the agency of cryptogamic parasites.

The apparent success which has followed the practical application of the antiseptic methods in surgery, has invested these micro-organisms with much interest, and at the present time they are the subjects of patient and careful study in many quarters. Those who have pursued this study most successfully assert that there are, probably, numerous other organisms possessing poisonous qualities, each of which has its own peculiar mode of action. This, in fact, has been recently demonstrated by Koch, a most patient and able investigator, whose statements are singularly lucid and apparently judicial in their fairness.[1] This author, premising that generalizations of new facts frequently lead to mistaken conclusions, insists that, in the study of this subject, every individual infective disease, or group of closely allied diseases, attributed to bacteria, must be separately investigated. He holds that the bacteria capable of producing disease are limited in number, and that these pathogenic bacteria comprise different and distinct species; that the only correct practical method of studying such bacteria as seem capable of producing constant noxious results, is by *cultivation* "from spore to spore." There is no better cultivation apparatus for pathogenic bacteria, he asserts, than the body of an animal. By this method, and the employment of certain improved optical appliances by which these particles which border on the invisible can be more readily and certainly recognized, this observer avers that he has demonstrated the certain existence of at least five artificial traumatic infective diseases. These are: *septicæmia*, in mice; *progressive destruction of tissue (gangrene)*, in mice; *spreading abscess*, in rabbits; *septicæmia*, in rabbits; *pyæmia*, in rabbits; and, partially, *erysipelas*, in rabbits. His investigations show, also, that these artificial traumatic infective diseases, both as regards their origin from putrid substances, their course, and the results of post-mortem examinations, bear the greatest resemblance to human traumatic infective diseases.

The most important demonstrated result attained by Koch, by using

[1] Investigations into the Etiology of Traumatic Infective Diseases. By Dr. Robert Koch (Wollstein). Translated by W. Watson Cheyne, F.R.C.S. London, The New Sydenham Society, 1880.

staining materials with an improved optical apparatus, is the discovery of the specific differences which exist between pathogenic bacteria and the constancy of their characteristic features, not only as to form, but as to the nature of the noxious effect produced by each. "A distinct bacteric form corresponds," as he says in his conclusions, "to each disease, and this form always remains the same, however often the disease is transmitted from one animal to another." In regard to septicæmia, he says: "I have performed these experiments on fifty-four mice, and always obtained the same result. . . . Further, when we succeed in reproducing the same disease *de novo* by the injection of putrid substances, only the same bacteric form occurs which was before found to be specific for that disease."

This statement, if confirmed, marks an important advance in our knowledge as bearing directly upon the exciting causes of destructive inflammation. The concluding words of Dr. Burdon Sanderson's "Report on the Causes of Infective Diseases," in 1875, marked the limit of justifiable assertion at that time. "If these infinitely minute organisms are present in every intense infective inflammation," says Sanderson, "we may be quite sure that they stand in important relation to the morbid process." It has now been apparently demonstrated that these organisms are present in every intensely infective inflammation thus far brought under sufficiently close investigation, and that they are not present in normal blood when tested as to its power of causing development by cultivation methods, excluding all sources of error, by Pasteur, Burdon Sanderson, and Klebs;[1] that they bear the relation to the disease following their inoculation of cause to effect; that there are different and distinct species of noxious bacteria; and that a positive and constant causal relation exists between certain infective diseases and distinct species of bacteria. Dr. Koch, by the employment of his improved methods, has arrived at a conclusion which is sufficiently important to justify repetition—"*that bacteria do not occur in the blood nor in the tissues of the healthy living body either of man or of the lower animals.*"

One of the novel and original results attained by this observer is of great interest. By the aid of an improved optical condenser he was able to verify at will the presence of exceedingly minute bacteria of the species *bacillus*, but much smaller than the *bacillus anthracis*, in the blood of mice artificially inoculated with putrid fluids, and dying, invariably, with symptoms of septicæmia. Along with this bacillus he observed in the neighborhood of the point of inoculation, another bacterium—a micrococcus—characterized by a very rapid increase, and the formation of regular chains. This micrococcus was never present in the blood. When a healthy mouse was inoculated with the blood of a septicæmic mouse, only the septicæmic bacilli were transmitted, and these were invariably found in the blood of the inoculated animal; but, when putrid fluid was injected, the bacillus was always found in the blood, and the micrococcus was always present in the tissues near the infected point—the other bacteria contained in the putrid fluid, and injected at the same time, dying out promptly because they did not find in the tissues of the living mouse a congenial soil.

By studying the *local* effect of the micrococci after an inoculation in the tissues of the ear, which is found to be a favorable locality for observation, it is discovered that these tissues are killed by their contact, and even by their proximity. In the tissues thus deprived of life, the parasitic growth is seen to multiply and spread more vigorously, extending itself especially towards living parts. As it advances, all of a sudden a densely agglomerated mass of leucocytes appears—

[1] Koch, op. cit., p. 14.

". . . . forming, as it were, a wall against the invasion of the micrococci, and this is the limit up to which these organisms may be found. They do not extend, even in the (dead) bloodvessels, beyond this line, the wall of nuclei (leucocytes) has no great breadth, and immediately beyond it comes the normal tissue. By the aid of high magnifying powers it becomes apparent that the micrococci do not reach quite up to the nuclear layer. On the side directed towards the micrococci the nuclei are undergoing destruction. . . . There almost always remains between the last remnants of the nuclei and the micrococci a line of considerable breadth, consisting only of gangrenous tissue, in which neither micrococci nor nuclei can be found."

Dr. Koch assumes that the action of these parasites in causing this spreading gangrene is somewhat as follows:—

"Introduced by inoculation into living animal tissues, they multiply, and, as a part of their vegetative process, they excrete soluble substances, which get into the surrounding tissues by diffusion. When greatly concentrated, as in the neighborhood of the micrococci, this product of the organisms has such a deleterious action on the cells that these perish and finally completely disappear. At a greater distance from the micrococci, the poison becomes more diluted, and acts less intensely, only producing inflammation and accumulation of lymph corpuscles. Thus it happens that the micrococci are always found in the gangrenous tissue, and that in extending they are preceded by a wall of nuclei which constantly melts down on the side directed towards them, while on the opposite side it is as constantly renewed by lymph corpuscles deposited afresh."

Various efforts were made to isolate these parasites—the minute septicæmic bacillus, and the gangrene-producing micrococcus—from each other, so as to study each separately by cultivation in different animals. But for a long time the efforts did not avail.

"Either pure septicæmia, or septicæmia along with progressive gangrene, was attained, never the latter alone. Chance led me to the proper method. A field mouse—which, as I formerly pointed out, possesses an immunity from septicæmia—was inoculated with septicæmic bacilli and chain-like micrococci. The experiment was made in the expectation that neither parasite would develop. This expectation, however, was not fulfilled, for, although the bacilli, as usual, underwent no development, the micrococci increased and spread exactly in the same manner as has been described in the case of the house-mouse. Beginning at the place of inoculation on the root of the tail, the gangrene spread onwards along the back, passing deeply among the dorsal muscles, and downwards on both sides to the abdominal wall. The animal died three days after the inoculation. The parts affected with the gangrene were partially denuded of epidermis and hairs, and contained chain-like micrococci in extraordinary numbers. The same micrococci were also found on the surface of the abdominal organs, although there was no visible peritonitis. The blood and the interior of the organs were, on the other hand, quite free from them. From this animal other field-mice, and from these again house-mice in various successive series, were subsequently injected, and always with the like result, viz., that only chain-like micrococci and, in their train, progressive gangrene, were obtained."

The ingenious observer who is responsible for these statements found equally interesting and positive results on investigating the spreading *cheesy* abscesses produced by putrid subcutaneous injections. He found a specific form of bacteric vegetation, proved its peculiar qualities by cultivation, and produced the same artificial infective disease at will. He discovered also another distinct variety of micrococcus which developed habitually in bloodvessels, and which possessed the unique quality of spinning around the blood corpuscles and inclosing them so as to beget thrombosis and positive embolism. The same growth also caused, by its contact, purulent (not cheesy) infiltration of the connective tissue. This new infective material was also propagated by cultivation, and proved competent to produce pyæmia, at will, by separate inoculation.

These results, demonstrating the agency of bacteria as the source of septic poisoning, to which, in searching for causes competent to excite the phenomena of destructive inflammation, we must give due consideration, have certainly much weight as evidence in favor of the antiseptic method of treating wounds. They are in accord with previous advances in the same direction. The connection of the *bacillus anthracis* with malignant pustule, and of the *spirilla* with relapsing fever, in man, established on the evidence of reliable observers, is generally received. It is a matter of recent history that the theory on which Lister based his antiseptic method, first promulgated in 1866–67, encountered, at first, very general scepticism. It has been followed by results, even in the hands of many who tried the method in practice without accepting the theory on which it was based, which, by their apparent confirmation of the theory, have led to a wider acceptance of its scientific truth. The results of the experiments on animals just quoted are of a nature to strengthen this belief.

It may seem out of place in this connection to speak of the practical results of antiseptic surgery, but, in the present attitude of this important question, the most available evidence as to the truth of the theory is furnished by the very considerable degree of success which has been attained by the antiseptic method of treatment. In striving to reach a correct estimate of micro-organisms as exciting causes of destructive inflammation, it is proper, therefore, to recognize that clinical experience tends to prove that the means which have been found hostile to the development of these organisms, are also growing steadily in reputation as remedies for the destructive phases of inflammation.

Beyond these exciting causes of destructive inflammation, what others offer themselves as worthy of serious consideration? Amongst the causes heretofore examined, the most worthy of notice in this connection are persistent local irritation from mechanical causes, and constant motion of an injured part, or the absence of the degree of quiescence necessary for the successful accomplishment of constructive repair. Hospital patients have been known to apply irritating powders—as of cantharides—to their ulcers, with the purpose of preventing their healing, and of delaying the time of their discharge from what they found comfortable quarters. But hindrances to healing of this character cease to act as such as soon as they are withdrawn, unless the predispositions of the patient are exceptionally unfavorable.

Surgical pathologists have heretofore sought for an explanation of wound diseases and wound infection in poisons generated under the circumstances of disturbed nutritive effort incident to every wound, and their formation has been ascribed to the decomposition and recomposition taking place, under these circumstances, in the unstable albuminous compounds forming the fluids of a wound. Robin has asserted that poisons of great virulence may be thus generated without the intervention of micro-organisms, basing the opinion upon the purely chemico-vital origin of the potent serpent venom.[1] In accordance with this view, Billroth of Vienna formed his hypothesis of the generation in the fluids of a recent wound of a "phlogistic zymoid"—a something capable of causing destructive inflammation, which acts like a ferment; and Verneuil, of Paris, suggested the theory of the formation of a "traumatic virus," by which deviations from the healthy process of repair of wounds is to be explained. Lister, of London, adopting Pasteur's views as to the agency of micro-organisms, finds a phlogistic zymoid in the conse-

[1] According to Mitchell the pure rattlesnake venom when freshly ejected contained no figured elements whatever. (Ut supra.)

quences of the struggle for life of the product of aerial germs. The position of Lister is less assailable because he has found means of destroying the vitality of the germs and of protecting wounds from their septic action, asserting, and demonstrating, that it is in the power of surgery to preserve a wound in an absolutely *aseptic* condition, and to protect the process of repair from interruption or complication by intrinsic causes. For the soluble poisons of chemical origin, no such antidote has been found.

As regards wound infection, the gross results furnished by clinical experience prove that subcutaneous wounds, and those which heal under a scab, and wounds protected by antiseptic dressing, are infinitely more secure from interruption of the simple process of repair than wounds which are not thus protected from the external air. The most probable explanation of this immunity from injurious complications is the exclusion of noxious organisms floating in the air. The converse of this proposition, that the unhealthy and destructive phases of the inflammatory process are directly due to contamination by these omnipresent aerial organisms, seems also for the far greater proportion of cases infinitely probable; but it awaits final confirmation. Before the recent discoveries of Pasteur and Koch, the antiseptic theory presented a sufficient basis of probability to have secured its acceptance by trained observers. Witness the evidence of Professor Tyndall as to the cause of the ill behavior of an abrasion of the leg which befell him on an Alpine expedition, and the experiments detailed in his paper on "Dust and Disease;"[1] witness the recorded experience of practical surgeons in all parts of the world, to be found in current medical journals. Of these latter witnesses, a certain proportion testify with reserve, and strive, in the true spirit of scientific skepticism, to explain their confessedly greater success otherwise than by the exclusion of poisonous germs. This success has been attributed accordingly to improvements in hospital hygiene, to the isolation of cases, to the observance of scrupulous cleanliness in dressings, and to more intelligent and careful nursing—all of which would rationally conduce to a greater degree of success in the treatment of surgical cases.

But evidence such as that furnished by Nussbaum, of Munich, is more positive in its character. This eminent surgeon testifies that pyæmia and hospital gangrene, which had been prevalent in his hospital wards for years, disappeared as soon as the antiseptic method of dressing wounds had been adopted, without any other material change as to the surroundings and nursing of his patients. Similar testimony has been given by many other hospital surgeons in Germany; and more recently, after noticeable reluctance and some ridicule of the new method, we have evidence that it has been seriously adopted in France, and the greater success following its use has been acknowledged by prominent Parisian hospital surgeons.[2]

The noxious influence of *putrid substances*, animal or vegetable, and their power when introduced amongst living tissues of producing various phases of destructive inflammation, has been long known, but the evidence as to their mode of action has been heretofore obscure, and even in some respects contradictory. The directly depressing effects of putrid exhalations upon the nervous centres, as proved by the nausea they produce, is due mainly to the hydro-sulphuric acid gas which is always present. Its action is somewhat like that of hydrocyanic acid, but less intense. Bernard injected this gas into the veins of a dog with the effect of causing utter prostration; but

[1] Fragments of Science for Unscientific People. London, 1871.

[2] Chirurgie antiseptique, etc. Par J. Lucas-Championnière. Paris, 1880. It seems proper to give due consideration to these incidents of current history in attempting, at the present time, to form a just estimate of the degree of importance of cryptogamic organisms as causes of the more grave forms of inflammation.

after a short time the symptoms of poisoning passed away, and the discoloration of a sheet of white paper saturated with a solution of a salt of lead and held before the nostrils of the animal, showed that the gas was being eliminated from the blood, through the lungs. There is no evidence that any phlogogenic power is exerted by this gas which so constantly accompanies putrefaction.

The notoriously dangerous effects which are liable to follow inoculation with the fluids of a recently dead body, as exemplified in wounds received in post-mortem examinations, have been ascribed to a poison formed by chemical action taking place just before or just after death. It is proved by experience that wounds received in examination of recently dead bodies, are more likely to be serious in their poisonous effects than those received after decomposition has set in. Hence the assertion, formulated by Robin, that putrefaction destroys animal poisons. Nevertheless, according to Mitchell, the venom of the rattlesnake, a typical animal poison, is equally deadly and characteristic in its action after it has been kept for weeks and has become "horribly offensive" and full of living organisms, as when perfectly fresh and containing, as he asserts, no figured elements whatever.

This leads to the question, which has been so much disputed, as to the nature of the putrid poison—Whether it is a soluble substance of chemical origin, or whether its poisonous qualities are due to the presence of living organisms? The much-quoted researches of Bergmann, and more recently of Panum, affirm the existence in putrid matters of a soluble substance of the nature of an alkaloid active principle, to which the name of *sepsin* has been given; and the validity of this conclusion has not been successfully disputed. But the still more recent researches of Pasteur, of Burdon Sanderson—into the nature of the cause of infective inflammation—and latterly of Koch, justify the belief that bacteria of many species—some of which are noxious and phlogogenic, some doubtful, and others entirely innocent—are also to be found in all putrid substances. At the present time, therefore, we must admit that putrid substances contain both chemical and bacteric sources of poisonous action.

In the well-known experiments of Dr. Anders, of Dorpat,[1] in which he showed that complete destruction of the organisms in a liquid which had been proved to be septic, in no way impaired its virulent action, the conclusion was to all appearances indisputable. Although the bacteria were removed from the virulent putrescent fluid by filtration through porcelain—a method not absolutely certain—yet no evidences of bacteric life could afterwards be discovered in it by the cultivation test, that is, by adding a drop of the filtered fluid to Pasteur's or any solution offering congenial soil. But these experiments are not final; the bacteria before their removal may, as a part of their vegetative process, have excreted certain *soluble* substances of a poisonous nature which remained in the filtered solution. Such substances, for example, as were diffused into the surrounding tissues by the gangrene-producing micrococcus discovered by Koch.[2]

The latter observer evidently recognizes the presence of poisonous agents of both chemical and bacteric origin in putrid fluids. In his researches undertaken to test the correctness of the conclusions of Coze, Feltz, and Davaine, putrid fluids, *e. g.*, putrefying blood, putrid meat infusion, etc., were injected under the skin in mice.

"The result of such an injection," he says, "differs much according to the nature of the putrid fluid, and according to the quantity which is introduced. Blood and meat

[1] Detailed in the first article in the seventh volume of the Deutsche Zeitschrift für Chirurgie.
[2] Op. cit., p. 42.

infusion, which have putrefied for a long time, appear to act less injuriously than fluids which have putrefied for a few days only. Of these latter fluids, as, for instance, of blood which has not putrefied too long, five drops is sufficient to kill a mouse within a short time. In this case marked symptoms may be observed in the animal immediately after the injection. It becomes restless, running about constantly, but showing great weakness and uncertainty in all its movements; it refuses food, the respiration becomes irregular and slow, and death takes place in four to eight hours. In such a case the greater part of the fluid injected is found in the subcutaneous cellular tissue of the back in much the same condition as before it was injected. It contains bacteria of the most diverse forms, irregularly mixed together, and as numerous as when examined before injection. No inflammation can be observed in the neighborhood of the place of injection. The internal organs are also unaltered. If blood taken from the right auricle be introduced into another mouse no effect is produced. Bacteria cannot be found in any of the internal organs, nor in the blood of the heart. An infective disease has, therefore, not been produced as the result of the injection. On the other hand, there can be no doubt that the death of the animal was due to the soluble poison, sepsin, which has been shown by the researches of Bergmann, Panum, and various other investigators, to exist in putrid blood. The animal has accordingly died not from an infective disease, but simply from the effects of a chemical poison."

This poison is, apparently, of the same nature as serpent venom, producing its deadly effect in a few hours by acting directly upon the nervous centres, without the intervention of bacteria. Subsequently when, in other experiments, a smaller dose of the putrid fluid was injected under the skin of a mouse, the symptoms made their appearance more slowly, and they were strikingly different in character, causing death in from forty to sixty hours, instead of from four to eight. Here the symptoms were evidently those of an infective disease, for the blood was found swarming with bacteria. When the blood of a mouse dying in this way was injected under the skin of a healthy mouse, death followed with precisely the same symptoms, namely, those of septicæmia. So that we are justified in concluding from these experiments that inoculation with putrid fluids may produce poisonous effects by a soluble chemico-vital poison analogous to serpent venom, acting in its peculiar way; and, also, by the slower action of living organisms, acting in an entirely different way.

Modes in which Poisons are Absorbed.—It is proper that, as surgeons, we should be familiar with the modes by which the poisons last under consideration gain access to the organism, with the view of possibly averting or preventing their effects. The human body enjoys a certain conservative protection against the influence of noxious agents. The action of all poisons is incidental and exceptional, and, it may be assumed, preventible, by the use of intelligence to supplement these conservative means. Foremost amongst them is the phenomenon of life itself, which has been defined as the power of resisting the tendency to chemical decomposition. It is matter of general belief that diminished vitality from any cause invites the invasion, and favors the development of parasites; and that the healthy and robust are more likely to resist causes of disease. Whilst this may be the rule, there are frequent exceptions to it. These exceptions arise from personal peculiarities conferring immunity, or from other conditions not yet within our grasp, which enable the organism to resist causes of disease at one time, whilst at another time it yields unaccountably to the same poisonous influences. Thus, the man who habitually handles dead bodies, as in the dissecting room, often enjoys excellent health, and the pathologist, in the daily habit of making post-mortem examinations, acquires an immunity from poisons derived from this source, which could not be counted on by another individual, even in apparently better physical condition, and perhaps fresh from country life.

The main avenue through which absorption of extraneous materials into the blood takes place is, as in the process of nutrition by food, the lymphatic vessels. Absorption may also occur through the walls of the bloodvessels. The epidermis is provided for the protection of the external surface of the body, and usually prevents absorption through the skin; but not under all circumstances. Substances, like mercurial ointment, which may be possibly forced by friction into the open mouths of the sweat ducts, are very certainly absorbed, as proved by the specific action of the drug which is constantly produced in this way. The same result undoubtedly follows baths containing corrosive sublimate in solution. Some of the subtle poisons lately under consideration may penetrate the unbroken cuticle, and, thus gaining access to the blood, give rise to infective diseases. This occurred to the eminent English surgeon, Sir James Paget, who suffered from spreading inflammation of the cellular tissue extending to the trunk and resulting in abscess, from which he barely escaped with his life after three months' illness. He gives a detailed account of his own case,[1] and attributes his illness to infection by a material absorbed from the dead body of a patient who had died from pleuritic effusion and pyæmia after lithotomy. During the post-mortem examination, the surgeon's hands were long soaked in the pleuritic fluid. He says: "Whatever the virus was, it soaked through my skin; I had no wound or crack of any kind."

This is an exceptional case, as the epidermis, when unbroken, is usually an efficient protection. Nevertheless, as we have seen, the simple contact of a "poison vine" will, with many persons, cause a crop of vesicles. But, as a rule, a puncture, however slight, or an abrasion, is present, and this offers an avenue of entrance to the poison. In the case of the late Dr. Hayward, of Boston, described also by himself,[2] he simply touched the mucous surface of the intestine to determine the existence of ulceration, at the post-mortem examination of a child dead from tubercular meningitis, and afterwards pricked his finger slightly in aiding to sew up the body, and within the week his finger had become gangrenous. Lawrence[3] details the case of a surgeon who died after similar infection, and who was not conscious of any lesion whatever until he discovered, by the aid of a magnifying lens, a minute puncture of the finger at a point which had become painful.

An abrasion of the male genital organ is a recognized avenue of entrance of the syphilitic virus; and a crack of the lip, in a healthy person, may become the seat of an infecting chancre, through inoculation by the saliva of another person who has the secondary mucous patches of syphilis upon the mucous membrane of the mouth. The mode in which absorption is effected in these cases, is no doubt through the open orifices of the minute lymphatic canaliculi of the integument; although it may take place through the walls of capillary bloodvessels, even when they are free from lesion. The absorption of the vaccine virus after partially scratching away the epidermis is a familiar example. The epithelium of mucous membranes is inferior to epidermis as a protective. Nevertheless, the pavement epithelium of the mouth being sound, it has proved safe to suck the venom from a serpent wound. Virulent substances undoubtedly become lodged in the minute mucous follicles, and are subsequently absorbed.

In subcutaneous injections, as of morphine, absorption is accomplished by the lymphatic canaliculi which open upon the surfaces of the connective tissue meshes. This method is usually employed in introducing putrid poisons into the bodies of the lower animals; but in many of Koch's experi-

[1] Clinical Lectures and Essays, 2d edition, page 320. London, 1879.
[2] American Journal of the Medical Sciences, N. S. vol. vii. p. 64.
[3] Lectures on Surgery. London, 1868.

ments on mice, the slightest incision by a scalpel charged with putrid matter was followed by infection, just as in the operation of vaccination. Any recent wound, therefore, which has not become covered by granulations, presents an absorbing surface through which poisons enter as instantaneously as after a subcutaneous injection. The internal surface of the uterus, after throwing off its contents, possesses the same quality as to capacity for absorption as a recent wound.

With regard to the absorbing power of a granulating surface, less clear opinions are held. Billroth dressed granulating wounds in dogs with putrid matter, and reports that after prolonged contact no infection followed. He infers, therefore, that granulations when perfectly healthy do not absorb. This conclusion, however, is contrary to what analogy would lead us to expect from surfaces consisting of living protoplasm capable of absorbing, and capillary vessels so accessible as to bleed at the slightest touch. It is matter of demonstration that a poultice of garlic applied to a granulating ulcer will affect the breath; and that dressings containing morphine, or stramonium, produce the specific effect of those drugs. This result is undoubtedly less certain than absorption through a recent raw surface, as of an incision; and the difference is mainly to be accounted for by the presence of the outward current of pus continually flowing from a surface of granulations, which tends to wash away foreign matters applied to it. But it would not be safe to rely implicitly upon the protective power of a granulating surface, even when perfectly healthy, although it possesses a certain degree of efficiency. All are agreed, however, that when granulations are unhealthy, or when the surface has been destroyed, even to a limited degree, their protective power against poisonous infection by absorption is not to be trusted. The barrier of granulations set up by the constructive inflammatory effort to limit advancing suppuration, or gangrene, has its true explanation in the fact that the noxious influence which is causing a spreading suppuration, or gangrene, has diminished in power, and is no longer able to keep up the destructive process. It is not correct to assume that the primary purpose of such a constructive barrier is, as it may at first glance seem to be, simply to resist the progressive absorption and injurious effects of a poison.

Very many poisonous substances gain access to the blood through the lungs, with their enormous absorbing surfaces designed—as regards gases and vapors—especially for this purpose. Carbonic oxide gas reaches the blood, and exerts its detrimental influence upon its red globules, as readily as the oxygen that vivifies them, and, to estimate correctly the promptness with which this process of absorption takes place through the lungs, we have only to recall the phenomenon, witnessed daily, of the production of anæsthesia by inhalation of the vapor of ether or chloroform. How far does this power of absorbing by the lungs include solid pulverulent and soluble substances? Happily it is limited to the transmission of the gases and vapors which can gain entrance through the glottis, and as to all other materials is exceptional. That it is within the range of possibility, is proved by the presence of finely pulverized carbon in the connective tissue outside of the air-tubes and in the bronchial glands, which must have traversed the lining membrane of the respiratory passages. But nature has furnished this membrane with a vibratile ciliated epithelium, with the especial design apparently of extruding solid materials from the air-passages, and of preventing them from reaching the air-cells.

The elder Mitchell does not dispute the belief that the impalpable cryptogamic germs to which he attributes contagious and epidemic fevers, get into the blood along with the air we breathe; and this question is also applicable to the germs which give rise to infective surgical diseases. This general be-

lief has not been seriously denied, nor even very carefully examined. It is probably, in the main, destitute of any serious foundation in fact. Apart from the argument derived from Nature's evident intention to protect the organism from the invasion of noxious agents, generally, and to prevent the passage of solid substances through the bronchial passages to the ultimate air cells of the lungs, especially, there are other considerations opposed to the belief that our bodies are so greatly exposed to harm through this avenue.

As regards noxious micro-organisms, Pasteur asserts that one of them, the *vibrio septica*, cannot develop when exposed to free oxygen, and infers the existence of the same peculiarity in other members of the family, describing them by the name—significant of this peculiarity of non-viability when exposed to oxygen—of *anaérobies*. Here, at once, is a valid source of protection against their noxious influence as introduced by the lungs. The ova of the echinococci gain access to our tissues through the digestive passages, and, undoubtedly, penetrate and traverse their walls, effecting their ultimate lodgment, by preference, in the liver. We can hardly assert that the more minute and indestructible bacteric germs—the *dauersporen*—might not reach the blood through the air passages. It has been held, and with probability, that the malarial poison becomes entangled in the saliva and introduced into the blood with the food; and the same avenue of entrance is of course available for bacteria and their germs. Here the well known power of the digestive secretions comes in play as a protective influence; but if they are impotent as to the ova of the *tænia echinococci* and the *trichina*, surely the same immunity may be assumed for the indestructible bacteric *dauersporen*. Possibly the germs of other noxious microscopic fungi may not be so tenacious of life as those of the *vibrio septica*, but it is evident that we must await a more extended knowledge of their nature and habits in order to pursue this subject intelligently.

The facts, however, which tell most strongly against the probability of the habitual introduction of infective poisons through the lungs, unless, indeed, they may exist in the form of gas, or vapor, are derived from clinical experience. When a case of infective disease, erysipelas, for example, is introduced into a surgical ward, as a rule, the patients with open wounds, alone, receive the infection. Alphonse Guérin states concerning his wound dressing of cotton-wool, so largely tried at the Hôtel Dieu of Paris, that patients whose wounds were thus protected escaped pyæmia, whilst their unprotected neighbors breathing the same air, almost invariably became victims of this disease. Nussbaum gives evidence that pyæmia and hospital gangrene have disappeared from his surgical wards since he adopted the practice of protecting all wounds antiseptically. Trélat states, before the Surgical Society of Paris, that since the advocates of Listerism have introduced their manifold antiseptic precautions into the hospital wards, pyæmia is no longer to be encountered there. Lister himself says freely that he cares but little how foul the air of a hospital ward may be, as regards its power of inducing infectious diseases, provided that antiseptics are thoroughly employed in dressing the patients' wounds. Now, if the infective poison of pyæmia habitually reached the blood through the lungs, protective means applied to open wounds, whilst the patient was constantly breathing the same infected air, would not prove thus effective in preventing it.

Symptoms of Inflammation.

The ordinary symptoms which characterize the condition of inflammation are mainly included under the cardinal signs recorded by Celsus: *redness* and

heat, with *swelling* and *pain*. To these, modern pathology adds *impairment of function* of the inflamed part, and the presence of more or less *fever*.

The symptoms of inflammation with which daily experience renders us familiar, are readily explained by the subjective phenomena which characterize the process, as revealed by microscopical study of tissues in which inflammation has been artificially excited in the lower animals; and by studying the causes which have been found, by experiments upon the lower animals, competent to give rise to the condition.

Thus, Redness, one of the most obvious and characteristic signs of inflammation, and the symptom, perhaps, most rarely absent, is explained by the increased amount of blood flowing into the vessels of the part, and for a time remaining there. The phenomena of afflux of blood to an inflaming part, and the temporary dilatation of the bloodvessels by which the increased amount of blood is accommodated in them, are the earliest and most striking of the changes which follow injury, and which constitute inflammation. With the explanation of the causes of these phenomena we are not at present concerned, beyond a recognition of the following facts. Redness may arise from *passive hyperæmia*, or congestion following any cause which impedes local circulation, whether the cause be a simple mechanical obstruction, or a functional failure, on the part of the vessels, as a consequence of an impaired quality of blood, or of defective vaso-motor nervous action. Redness may also arise from *active hyperæmia*, as in blushing, or in the flushing of the face which has a reflex gastric origin, or as provoked by any of the more common exciting causes of inflammation, which have proved incompetent to produce the condition beyond causing an afflux which has ceased at the stage of active hyperæmia. In neither of these cases is the redness regarded as a symptom of inflammation. The line of distinction between persistent active hyperæmia and inflammation, is usually considered to be marked by the occurrence of exudation. Nevertheless we should deceive ourselves if this view were regarded as final. There is a certain degree of identity between hyperæmia, or congestion, and inflammation; and the reason why the redness produced at will by roughly applying friction to the conjunctiva, or to the skin, disappears shortly, instead of going on to exudation and cell germination, is not entirely clear. After hyperæmia of long duration, serous exudation does take place, not rarely, and previous to its occurrence there is increase of bulk, and also of heat, in the congested part. After death, capillaries which have been thus subjected to distension are found to present fusiform or ampullar dilatations.[1]

Phenomena attributed to hyperæmia occur in a lower extremity after a successful ligature of the femoral artery. The collateral circulation, even when ample, is at first retarded by cutting off the arterial *vis a tergo*, and although for a day or so the heat of the limb is distinctly greater than that of the sound one, this difficulty is shortly adjusted, and the occurrence of inflammation from this cause is almost unknown. The redness, from capillary distension, that follows pressure of any duration which has been suddenly removed, is usually called hyperæmia, which, in this form, causes overgrowth of the epidermis, and explains the production of corns on the feet. The complete removal of the contents of a habitually distended bladder is in most instances followed by passive congestion, which terminates in patches of ulceration and gangrene of the vesical mucous membrane. The systematic use of a local hot air bath to stimulate the growth of a wasted limb, in a child, has resulted in the production of a distinctly stronger growth of hair upon it, evidently the result of the surface hyperæmia provoked by the heat.

[1] Cornil and Ranvier.

It would seem, therefore, even from these few facts, that the condition of hyperæmia has both a constructive and a destructive aspect, determined by the circumstances which give rise to it.

Redness is usually light in tint, at first, and it becomes deeper as the inflammation increases in intensity. When a poison is present in the blood, the redness may assume a livid tint, as in certain grave phases of the eruptive fevers. The eruptions of syphilis are, for the most part, copper colored; after a snake-bite the redness is usually mottled. When the over-distended capillaries of an inflamed surface rupture, the redness shows darker points of extravasation. The blood may be removed from an over-distended vascular network by temporary pressure, as in the earlier stages of a conjunctivitis, and the redness, for the moment, entirely removed, the white sclerotica showing through. Its dependence upon the presence of blood in gorged blood-vessels is thus demonstrated. The term *arborization* is applied to a vascular area or network of vessels, thus distended with blood, when the outline of the vessels is still distinguishable. When redness presents itself as an uniform sheet, as in scarlatina, or erysipelas, it is not easily distinguished from staining by extravasation or by transudation of blood-colored serum through the capillary walls, especially when the redness cannot be made to disappear by temporary pressure. In the beginning of inflammation in the non-vascular tissues, such as the cornea and cartilage, redness is not recognizable.

The increased HEAT of an inflamed part is to be ascribed to the greater amount of red blood present in the part, and to the greater activity of the vital processes, normal and abnormal, which are taking place in it and evolving a corresponding increase of the local temperature. When fever is present, the higher temperature of the blood aids in increasing the local heat.

The presence of increased heat in an inflamed part, when not too far removed from the surface, is usually recognizable by the patient, but not so readily and certainly as by the hand of another person. It is verified by comparison with the temperature of another part of the body. Thus, in a knee-joint, when inflammation is suspected, its surface temperature is compared with that of the opposite knee. It has been proved by experiment[1] that this increase of local heat is mainly the result of the local causes already mentioned; it has rarely been found to exceed, and in most cases it has not reached, the temperature of the blood. Since the very general clinical use of the thermometer this fact has been amply verified. Ingenious instruments have also been employed for accurately measuring local temperature. There is reason to believe that the temperature of inflamed parts is not so readily lowered by evaporating lotions, or the application of ice, as that of corresponding sound parts.

The SWELLING in inflammation is due in part to the greater quantity of blood present in the dilated vessels, and in part to the materials, liquid and solid, which exude through their walls, as well as to extravasation from rupture, which often occurs in consequence of the force attending the afflux of blood to the inflammatory focus. It is also due in part to cell germination and to the formation of new capillary vessels, which, as the injured tissues revert to their embryonic state under the incitement to constructive inflammation, contribute materially to their increase of bulk. The occurrence of swelling in a part, without other signs, is not very significant of inflammation, for it is liable to occur frequently from other causes. Nor is it always present in inflammation, especially at first, as, for example, in simple osteitis,

[1] John Hunter; Andral and Gavarret; Marey.

and in inflammations of serous and mucous membranes, before exudation has taken place into the connective tissue underlying these membranes. In fact, the looseness of texture and distensibility of the connective tissue of an inflamed part is a condition necessary for the production of this symptom in any considerable degree.

The PAIN so rarely absent in inflammation is explained by the local irritation of the nerves of a part by the causes which have excited the condition, as by the contact of a splinter, or an acrid poison, or by a burn, and also by the tension and partial laceration of nervous filaments by any of the causes which beget swelling. The sudden darting pains which are felt in an abscess approaching maturity, mark the rupture of small nerves stretched beyond their capacity of resistance by the growing bulk of the collection of pus. Pain alone is often a valuable sign of a deep-seated local inflammation, where its distance from the surface of the body has prevented the recognition of heat, redness, or swelling. The first symptom of a subfascial abscess of the iliac fossa is pain in extending the thigh. The knotted hardness and keen sensitiveness over the track of the lymphatic trunks precedes the redness in lymphangeitis. The extreme tenderness to the touch of the lymphatic gland in front of the ear, is one of the characteristic prodromata by which we are able to foretell an outbreak of erysipelas of the face. The exquisite sensibility on pressure over the vein, is the earliest diagnostic symptom of a phlebitis.

Pain varies much in character according to the nature and ordinary sensibility of the parts affected. When they are unyielding, as in periostitis in the socket of a tooth threatening abscess, or in whitlow—which involves the dense fibrous structures surrounding the bone at the end of a finger—or in a crisis of gout, the pain amounts to torture. In inflammation of the substance of the testis, enveloped by the unyielding tunica albuginea, or of the tissues within the globe of the eye, or in the external meatus of the ear, or in the interior of bone, pain is notoriously severe. Pain of a pulsatile or throbbing character is caused by the increased force of the smaller arteries bringing blood to the focus of inflammation, and by the obstruction to free circulation caused by the swelling, and possibly increased by stasis, at the centre of the inflamed area. The condition of strangulation, in which the pain is excessive, takes place when the veins of an inflamed part are obstructed by the pressure of the swelling, so that the blood cannot escape through them whilst it is still being brought by the arteries. This is liable to occur in epididymitis and acute orchitis, in which the turgid vessels of the spermatic cord are encircled by the unyielding borders of the external abdominal ring. On the other hand, pain is not rarely trivial, or even entirely absent, in grave inflammations where the parts affected are of soft consistence and have free room to swell, as, for example, in pneumonia.

Pain presents variety in quality as well as in degree, and expressions are in common use for indicating certain of its varieties. Thus where a nerve of any size is subjected to pressure, as from a collection of pus, the pain is *aching*, sometimes *tingling*, as when the ulnar nerve where it lies behind the internal condyle of the humerus has been bruised. In many skin inflammations pain takes the form of *itching;* in others, again, this form of pain is entirely absent, as in the eruptions of syphilis. An abscess forming in the head of the tibia causes a *boring* pain, which is distinctly worse at night. An abscess forming slowly in soft parts produces a *sense of weight*, or a *tensive* pain; when about to point it gives rise to *lancinating* pain. The pain of an erysipelas is described as *burning* or *sore*. Thus the pain of inflammation has a language of its own, a familiarity with which is useful in diagnosis, espe-

cially in determining the seat of an abscess. As pain is a common symptom in other and non-inflammatory affections, its value as a symptom of inflammation is to be determined in many cases by the coexistence of other corroborative signs.

Impairment, or more or less Entire Abolition of Function, is almost always present when a part, or an organ, is the seat of serious inflammation. The function of the eye is suspended in iritis; in mumps there is dryness of the mouth on the side of the parotid gland affected, from arrest of its secretion; the voice is lost or impaired when the *chordæ vocales* are involved in the local inflammation in a laryngeal catarrh; muscle contracts with difficulty when inflamed, and its contraction is accompanied by peculiar and severe pain. The "stitch in the side" of a pleurisy impedes respiration, and the exudation in pneumonia, if sufficiently extensive, extinguishes this function. In peritonitis, the diaphragm contracts imperfectly, and the respiratory movements are limited to the thorax. In short, in every severe local inflammation there is a certain degree of interference with function throughout the whole economy, and this is especially marked in connection with the condition of fever, which, under such circumstances, is rarely absent.

Locally, the conditions of *textural* life are altered in a greater or less degree by their participation in the changes which constitute inflammation. These changes involve, as we have seen, the conditions of local blood supply, and therefore nutrition is disturbed as well as innervation. They include at first increase of local heat, and arrest of glandular and follicular secretion, the result, apparently, of the intense active hyperæmia, causing dryness. In certain phases these earlier changes are well shown in simple cutaneous erysipelas. After this disease has run its course in the scalp, the epidermis exfoliates, and the hair falls, showing that the function of the hair bulbs has been suspended. It is to be noticed, however, as illustrating the characteristic quality of the inflammatory condition—the absence of an intrinsic destructive tendency—that old surface-ulcers, which have been lingering in an indolent condition and resisting means of cure, often get well promptly after an attack of erysipelas involving the integument around them. The explanation of this not uncommon incident is due, apparently, to the enormously increased quantity of blood brought into the parts during the inflammatory crisis, which, whilst it interrupts temporarily the growth of cuticle and hair, seems to incite a purely reparative effort in the tissues involved in the pre-existing lesion. The ultimate tendency in all tissues when involved in inflammation is, as we know, to revert to the embryonic condition, as a preliminary stage to reconstruction; and the parts involved in an indolent or languidly granulating ulcer, having already attained this stage, in a degree, are appropriately stimulated, by the incidentally increased blood supply accompanying an invasion of cutaneous erysipelas, to take on a new and successful effort at reconstruction.

Short of complete reversion to the embryonic condition, that is, the state of "indifferent" or "granulation" tissue, there are endless phases of local textural change resulting from inflammation which are daily recognizable by the clinical eye. These changes affect inflamed parts variously, as regards their bulk, their consistence, and their general aspect and quality.

Traumatic or Inflammatory Fever.

As a symptom of inflammation, *fever*, in some degree, is rarely absent after a wound or injury of any gravity; and its more common form is known

as "traumatic" or "simple inflammatory" fever. It is more likely to be slight in its manifestations, or even to be entirely absent, after simple and uncomplicated injuries, such, for example, as an incised wound which is uniting promptly by the first intention. After a contused wound or a partial crushing, traumatic fever would be more certain to occur and to be well marked, and to merge, possibly, into a graver form of surgical fever.

As a rule, fever makes its first appearance in the evening of the day on which a serious injury, say a compound fracture, has been received, following the reaction from the collapse or shock of injury which takes place more or less slowly according to the gravity of the case. If a wound involve perfectly healthy tissues, and has been promptly and properly cared for, or if it be a subcutaneous lesion, such as a simple fracture, febrile symptoms may not show themselves for twenty-four hours, or even a longer time, or they may, possibly, not appear at all.

In a healthy young man whose hand was utterly crushed between cog-wheels, requiring primary amputation, fever did not manifest itself for thirty-six hours, and was then limited by a temperature of 100° Fahr., the wound uniting by the first intention except where the ligatures of silk prevented; and before the sixth day the symptoms had disappeared.

In an amputation at mid-leg for a crushed foot, through parts not entirely sound, fever showed itself the same evening, and continued until the beginning of the second week.

In a similar case, in which the operation, through reluctance to submit to mutilation, was delayed, fever came on within a few hours; by the end of the week it had assumed a septicæmic character, and before the end of the second week it had terminated fatally, the temperature having risen to 104°+ Fahr., the blood, after death, coagulating imperfectly.

This case affords an example of an unfavorable termination of what seemed to be at first simple traumatic or inflammatory fever, and it illustrates the mode in which traumatic fever reaches this exceptional termination, as observed clinically, in fatal cases, namely, by merging into another form of surgical fever attended by greater danger to life. This difference in the character of the accompanying fever marks also the distinction which is assumed to exist, in the language of the day, between a healthy or constructive inflammatory process and an unhealthy or "infective" inflammation.

As a rule, traumatic fever is moderate in character, and terminates early and spontaneously. In connection with subcutaneous wounds and injuries, as in a case of simple fracture, it is either entirely absent or very mild and transient; and the same is true, for the most part, of wounds which have been thoroughly protected by antiseptic dressings, and in which catgut ligatures have been employed.

The aspect of a patient on the invasion of traumatic fever becomes slightly altered; his countenance is somewhat pinched and anxious; he is a little restless, apt to resent disturbance, and awakes frequently from his sleep. He is conscious of feeling fatigued, hot, and thirsty, and has usually a dry mouth. The tongue gradually becomes coated, and there is little or no desire for food. The urine is scanty and deeper in color. The pulse is more frequent than it should be, and the thermometer, under the tongue, shows a decided increase of temperature. Although the patient may feel slightly chilly on exposure, simple traumatic fever is not usually ushered in by a rigor, and the temperature rarely exceeds 102.5° Fahr. The fever reaches its climax in about thirty-six hours; it may continue, with a slight remission in the morning and a corresponding increase towards evening, for two, three, or four days. About this time the fever begins to decline, the temperature diminishing, and the pulse gradually returning to the natural standard; so that, at the end of a

week, the febrile movement has ceased. Not infrequently, when suppuration takes place in a wound at the usual period, say from the third to the fifth day, the traumatic fever declines coincidently with the appearance of pus and the diminution of the local swelling and tension.

This is the typical course of traumatic or inflammatory fever. If it does not disappear promptly within this limit of time, there is reason to suspect deeper suppuration, or some other complication of the local inflammation, to account for the continuance of the febrile symptoms, which can no longer be ascribed to simple traumatic fever, but threaten to assume the character of septicæmia, pyæmia, or hectic. These phases of febrile action will be considered hereafter; at present we shall confine our remarks to the simpler affection.

The personal quality of the patient as to constitution, condition of health, and surroundings, besides the extent and locality of the injury, have their influence in producing the various phases of traumatic fever encountered by the surgeon, and in determining their gravity; but this influence, like the cause and nature of the fever itself, is both complex and obscure. When an inflammation is rapid in its development, characterized by strongly marked symptoms, and attended by much local excitement, it is said to be *acute*, and, under these circumstances, the symptoms of the accompanying traumatic fever are well marked and more intense. The term *sthenic* is used to designate fever of this type; its occurrence is not incompatible with a previous high grade of sound health. Its acme or *fastigium* is rapidly attained, and its defervescence or *lysis* is usually prompt and complete. On the other hand, in an organism which has been previously the seat of chronic disease, a new injury is not likely to be resented by a high grade either of inflammation or of traumatic fever.

A boy, aged 17, was subjected, at the New York Hospital, to amputation of the thigh at its lower third for "chronic synovitis" of the knee-joint. The next day his habitual aspect of depression had distinctly improved; his tongue was noticeably less red; his pulse was less frequent than the day before the operation; he had slept more continuously during the night—apparently in consequence of entire relief from the aching joint pain. In this case no febrile movement occurred until the evening of the third day, when there was slight heat and tension of the stump and a moderate rise of temperature. On the next day there was a flow of pus along the track of the ligatures, the tension of the stump had subsided, the general temperature had fallen, and all evidence of traumatic fever had disappeared. Subsequent recovery was unusually rapid and complete. Except where the presence of the ligatures had provoked suppuration, the inflammation following the amputation was limited entirely to its *constructive* phase.

Primary amputation of the thigh rendered necessary by injury is rarely followed by a result so innocent, as regards inflammatory or febrile reaction, as in this amputation for disease. Even in health, the suddenness of an injury favors subsequent febrile reaction. Within certain limits, previous training by illness and pain renders the organism more tolerant. The significance of these facts is embodied in the surgical doctrine that secondary amputations for disease involve less danger than primary amputations for injury. They are introduced here as illustrative of traumatic fever from a clinical point of view, awaiting a solution, from physiology, of the difficult problem of the nature and immediate cause of fever, by which they are to be ultimately explained.

What actually constitutes the condition to which we give the name of fever, may be stated, in plain terms, without speculation. Clinical observation, aided by research and experiments on the lower animals, has led to certain conclusions which are admitted by all. The essential feature of fever is an increase in the temperature of the blood; and this increase may reach

eight, or even, in extreme cases, ten degrees Fahrenheit. With the certain knowledge that the organism possesses a self-regulating power as regards its temperature, which, under all the varying circumstances of climate, preserves the blood at or about the same degree of heat—99° Fahr.; when, shortly after the infliction upon the body of a physical injury, this temperature is observed to rise, as indicated by an instrument of precision, a certain number of degrees, and to retain its abnormal elevation for some hours, this phenomenon, alone, justifies the observer in the conclusion that fever is present. All the other features of the state of fever arrange themselves around this central phenomenon, which is pathognomonic. The injured person may not be conscious of this increase of heat. He may, in fact, and generally does, at first, feel distinctly chilly. What is technically called a *chill*, or *rigor*, that so commonly occurs at the onset of fever, coincides with a rise, more or less sudden and rapid, in the temperature, as indicated by a thermometer placed beneath the tongue of the patient. He may be shivering with cold, and yet the thermometer may indicate a rise of three or four degrees. This shows that the subjective sensations of the patient cannot be trusted. His skin may be biting hot to the hand of the surgeon, and yet he may be shivering. At a later period he becomes unpleasantly conscious of the increased heat of his body; but even now chilly sensations may alternate with the consciousness of intense heat.

These phenomena accompany the *invasion* of most of the graver forms of surgical fever. Indeed there is a certain significance of gravity always conveyed by the occurrence of a chill in a surgical case; and the intensity and duration of a chill is properly regarded as an indication of the degree of danger present. But, as a rule, in the milder forms of traumatic fever the chill is slight, and often entirely absent.

Coincidently with the increased temperature of the blood in fever, there are other evidences of derangement in the heat-producing machinery of the body, besides the somewhat illusory sensations of the patient himself. There are evidences that tissues are undergoing premature destruction by combustion, which, in the ordinary balance of nutrition, escape in consequence of the daily provision of an adequate supply of material for keeping up heat, by food. In fever, appetite is wanting, digestion and assimilation are reduced to a minimum, and yet heat production is kept up to the standard of health. Hence the excretion of urea is almost if not quite tripled, as a result of the combustion of albuminous materials, *e. g.*, blood plasma, blood corpuscles, the sarcous element of muscular tissue, etc. Hence the increase of potassium salts in the urine, the doubled excretion of carbonic acid, the absorption of adipose tissue, and the consequent emaciation which always accompanies fever. In the dogs, so carefully watched by Weber in his valuable experiments undertaken to elucidate the nature of fever, emaciation took place more rapidly in dogs with fever, eating as much as they could be made to eat, than in dogs, under similar circumstances, but without fever, who were deprived of all food. In other words, emaciation took place more rapidly from fever, than from inanition. Clinical observation affords confirmation of this statement.

It is thus evident that heat production in the human body, during fever, is, so to speak, an expensive process. Although the heat in fever does not transcend the aggregate of health, it is kept up by the forced consumption of substances in the body too valuable to be consumed for the purposes of fuel—the supply of heat-producing food from without, through the ordinary channels, being cut off. We are forced to conclude, therefore, that fever, like inflammation, is essentially a disorder of nutrition.[1] This position, based on the

[1] The following quotation contains the conclusions as to the nature of fever reached by Prof. Wood from his recent experimental researches, which constitute the latest as well as the best evi-

best evidence thus far attained, brings us however but little nearer to a knowledge of its essential nature and immediate cause.

As throwing light upon the causes of surgical fever, it is worthy of notice that, in his elaborate experiments, Senator resorted to a subcutaneous injection of fresh healthy pus for the purpose of producing the state of fever in his dogs artificially. He habitually employed this pyrogenic device, and it always succeeded. In two or three hours after the injection of the pus, the temperature of the blood began to rise until it reached a certain figure, at or about which it remained for two days or so, and then, unless the injection was repeated, it subsided; meanwhile the animal manifested all the symptoms of fever. This affords a demonstration of what has been recognized as the fever producing, or "infective" power of the products of ordinary inflammation. On the basis of these and similar experiments, Dr. Sanderson[1] formulates, very concisely, the conclusion that "fever is the product of a fever-producing cause contained in the blood or tissue juices, the morbific action of which on the organism is antecedent to all functional disturbances whatever." He also employs the term "infective agent" as synonymous with "fever-producing cause" and speaks of fever as "from first to last a disorder of protoplasm." Prof. Wood, in his conclusions, expresses the following opinion concerning the causes of fever: "In most cases of fever, and probably in all cases of serious fever, there is a definite poison circulating in the blood, the poison sometimes having been formed in the system, sometimes having entered the organism from without."

This may be regarded as a fair exposition of the doctrine of the day as regards fever. The theory so long prevalent that fever took its origin in disorder of the nervous centres, has been given up by recent authorities in surgical pathology. Billroth has rejected it; so also have the French encyclopedists. All avow a belief in a material cause; and the search for this material cause, which includes also the cause of inflammation, is, at the present time the foremost problem of surgical pathology. It has been thought to exist in the "infective quality of the products of inflammation;" in putridity—as in the soluble "sepsin" of Bergman—the analogue of serpent venom; and finally, in the micro-organisms which have been proved to be so intimately associated with putrefaction. There seems to be no valid reason why there should be a solitary material, pyrogenic, or phlogogenic principle. There may be, and judging from clinical experience there are, probably, multiple material causes both of surgical fever and of inflammation; and some of them are, apparently, being identified.

It is questionable if it be wise to reject the influence of the nervous system so entirely in the search for these material causes of fever. That its influence has been heretofore vaguely exaggerated, is proven, as one of the direct results of more certain and accurate knowledge; but, as in all fluctuations in human opinions, there is danger that the opposite views may be carried to ultraism, and that belief may become a matter of fashion. The writings of the great English masters of surgery in the early part of this century offered little that the mind could grasp in explanation of the nature and causes of inflammation

dence on the subject since the lectures on calorification of Claude Bernard, in 1876: "Fever is a complex nutritive disturbance in which there is an excessive production of such portion of the bodily heat as is derived from chemical movements in the accumulated material of the organism, the surplus being sometimes more than the loss of heat production resulting from abstinence from food. The degree of bodily temperature in fever depends, in greater or less measure, upon a disturbance in the natural play between the functions of heat production and heat dissipation, and is not an accurate measure of the intensity of the increased chemical movements of the tissues." (Fever: A Study in Morbid and Normal Physiology, p. 240. By H. C. Wood, A.M., M.D. Published by the Smithsonian Institution, Washington, D. C., 1880.)

[1] Report on the Causes of Infective Diseases, 1875.

and fever. Abernethy, Cooper, Wilson Philip, Travers, whose doctrines and phrases were on the lips of all teachers, and dominant in the schools, referred the obscure phenomena of these conditions to *sympathy*, and *constitutional irritation*—somewhat empty phrases; and Hunter, the greatest of all, evidently—to us of this generation—owes his pre-eminence to his close and able observation of Nature, whom he questioned through experiments upon animals; and to his fidelity to her teachings. This most fertile of all our sources of exact knowledge, that is, knowledge which has proved reliable, and of practical value in physiology and pathology, namely, experiments upon animals, was undervalued by these contemporaries of Brown and Broussais, because it was the fashion to believe that the phenomena ascribed to the influence of the mind and nervous system, *e. g.*, "sympathy," "constitutional disturbance," and "constitutional irritation," could not be adequately developed in the lower animals, and that the knowledge thus acquired could not therefore be profitably applied to man. In fact there are a few of the descendants of these sentimental recusants still raising their voices in opposition to vivisection.

If we omit Hunter, the real value of the writings of the authorities just cited, and a certain charm which they undeniably possess, will be found in their great ability as clinical observers and vivid portrayers of the symptoms of disease, and not in the interpretation of the phenomena they witnessed. Their opinions were too often warped by theories prevalent at the time, which have since passed away. The material results of the more practical researches of the present generation, promise to form permanent additions to our knowledge; as, for example, the fact just cited from Senator that the injection of a little fresh pus will invariably produce fever in dogs, or that of the production of more intense and fatal fever by injection of putrid matter, as proved by Billroth and O. Weber. But it is still regarded as possible that substances may be elaborated within the organism, by abnormal chemico-vital changes, under the influence of temporarily perverted nervous action, which may give rise to fever, or to inflammation, as certainly as the injection of fresh pus beneath the skin, or of putrid matter into the veins. The clinical facts are undisputed that the simple passage of a sound through the urethra may cause a chill and fever, and that a sudden fright may so affect the quality of a nursing woman's milk as to produce a poisonous effect upon the nursling. If an influence transmitted through nerves is competent to cause a change in a glandular secretion, begetting a poison, why may not the blood be similarly affected in the collapse following a severe injury, in which the generation of nerve force by nerve cells is temporarily suspended? It is not easy to submit such a question to the test of experiment, and it is not desirable to speculate; but it is certainly wise not to lose sight of these, and similar phenomena, as bearing upon the causation of fever.[1]

Mr. Savory has quite recently entered a plea for consideration of the claims of the nervous system as bearing upon "constitutional disturbance," which may possibly be referred to with profit in this connection. This eminent surgeon contends that fever may arise from "nervous" as well as from "material" sources, and that the forms of fever thus produced present many symptoms in common, such as malaise, and rise in temperature; but that, where there is actual blood-poisoning, chills and sweats, with great and sudden rises

[1] In his "Leçons sur la Chaleur Animale" (Paris, 1876, p. 445), Claude Bernard concludes that fever is nothing more than an exaggeration of the physiological phenomena of combustion, in consequence of interference with the nerves whose office it is to control and regulate these phenomena. This interference may be reflex—as from a wound or injury; or direct—as from section of the spinal cord. On this point Prof. Wood (*ut supra*) concludes that "the maintenance of the normal temperature and its rhythm is dependent upon the nervous system which, within certain limits, controls both the production and dissipation of animal heat."

of temperature are present, ending in congestion, inflammation, and suppuration.[1]

Aided by clinical evidence, we may conclude, concerning the duration of ordinary traumatic or inflammatory fever, that whether it arises from a *nervous*, or a *material infective* cause, or from a combination of both, in the great majority of cases it tends to get well spontaneously, in a few days; the vital powers being competent to set to rights the *nervous constitutional disturbance*, or to resist and prevent the propagation, within the organism, of any material or infective fever-producing agents. This point, that is, the tendency of traumatic fever to spontaneous and speedy recovery, should be clearly conceived, in view of its bearing upon the question of treatment.

In accordance with the doctrine of the day already recognized, and leaving nervous influence out of the question, the theory which best explains the occurrence of traumatic fever is the absorption of poisonous material from the wound into the circulating current, the presence of which poisonous material in the blood causes its rise of temperature. If the traumatic fever persist beyond the five or six days assigned as its usual duration, or if it recurs in the form of "secondary" fever, the most probable explanation of these phenomena will be found in lack of power in the organism to prevent the propagation within it of the infective material.

The terms *infective* and *non-infective*, introduced by Simon and Sanderson, have been so generally adopted in treating of surgical inflammations and fevers as to require special definition. They involve a belief in a simple form of inflammation which never occurs without a cause, and which tends to disappear spontaneously as soon as its cause is withdrawn. "An inflammation," says Sanderson,[2] "which is more or less exactly limited in duration and extent by the limits of the injury which has caused it, may, with scientific precision, be designated a simple or normal inflammation," that is, *non-infective.* On the contrary, "an inflammation which spreads and endures beyond the direct and primary operation of its cause, which induces similar inflammations in other parts, and disorders the vital functions of the whole body, has in it something beyond the effects of the injury, and may be properly termed *infective.*"[3] In the latest English systematic work on pathology[4] this is spoken of as "one of the most important divisions of inflammation;" and it is stated that, "in all infective inflammations the formation of the infective substance appears to be due to the presence of minute organisms, these organisms, in the ordinary non-specific inflammations, being the common septic bacteria." It cannot be said to be demonstrated that the infective properties undoubtedly possessed by fresh healthy pus, as the typical product of inflammation, are due to micro-organisms. If so, the vital quality which

[1] In his opening address, as President of the Surgical Section of the British Medical Association, in August, 1880, Mr. Savory expresses himself as follows: "For many years the belief prevailed that disturbance of the whole body, or the illness produced by local mischief, was evoked through the nervous system, and hence the phrases 'sympathetic inflammatory fever,' and 'constitutional irritation;' and this great doctrine naturally grew in force as the functions of the nervous system came to be better understood. The discovery of reflex function went very far to explain the mode of action of the nervous system as the channel of sympathy between the various structures and organs of the body. But then came the knowledge of what is now known as 'blood-poisoning;' and from the time, not far distant, when this first dawned on the minds of surgeons, it has become so rapidly developed that now it threatens to, nay actually does, exclude the older view; so that with many, at the present time, *constitutional disturbance*, in this relation, means, always, the phenomena of blood-poisoning, in some one or other of its various forms." He then proceeds to show that both these forms of constitutional disturbance occur, and that although they are often confused, it is of the highest importance to distinguish each of them.

[2] Report of an Experimental Study of Infective Inflammation, 1872, p. 48.

[3] Ibid. p. 49.

[4] An Introduction to Pathology and Morbid Anatomy, p. 215. By T. Henry Green, etc. London, 1881.

enables a healthy organism to resist disease is competent to prevent their multiplication; for the infective quality, as in Senator's dogs, is not always persistent. But this reasoning would not apply to the inoculations of mice by the septicæmic bacillus, as recently described by Koch. Thus the existence of an indefinite number and variety of infective agents is again suggested as probable.

The preceding remarks include all that can be properly said here concerning the more serious forms of surgical fever. When the ordinary traumatic or inflammatory febrile movement begins to assume more grave symptoms, and persists, taking on the aspect of what the older surgeons, after Abernethy, called "irritative fever," with a dry tongue, more rapid pulse, more altered aspect, and more positive emaciation, and possibly diarrhœa, with or without a coincident unhealthy condition of the wound, and with efficient provision for drainage of the wound—for this category of symptoms we have no more probable explanation to offer than *blood-poisoning*. When putrescent material has been absorbed into the blood, in larger quantity than the organism can resist or throw off, as from a contused or unhealthy wound from which there has been no ready avenue of escape by drainage, the symptoms which have been ascribed to traumatic fever become intensified in the manner just described; then septic poisoning has almost certainly taken place, and the condition of the patient comes within the definition of *septicæmia*. Or, after an interval during which the traumatic fever may have almost or entirely ceased, during the second week after the injury, or later—even as late as the second month—the wound, meanwhile, showing, perhaps, no serious change from a healthy aspect—a chill may suddenly occur, followed by profuse sweating and the characteristic chill-recurrence of *pyæmia*.

Under the titles of septicæmia and pyæmia, these phases of surgical fever will form the subject of a separate article.

Inflammatory Exudations.

Clinically, there are conditions and appearances of surgical disease resulting more or less directly from the presence of inflammation, and belonging to the category of its symptoms, which are caused by *transudation* or *exudation* of materials through the capillary vessels. Exudation has been aptly described as the connecting link between the intra-vascular and extra-vascular manifestations of inflammation; and it has also been spoken of as the material limit by which hyperæmia is distinguished from true inflammation. The materials which exude through the walls of the capillary vessels, vary much in character. They appear on the surface of membranes, as in diphtheria; in the interior of the body, as in local œdema, or in hydrocele; or on the surface of recent wounds, as in the form of plastic lymph, where the exudation tends distinctly to the formation of new tissue. Pathology does not explain the difference between transudation and exudation with sufficient accuracy to justify any clear or positive distinction between the terms. As a rule, the more fluid *transudations* consist of a phosphatic, saline liquid, containing albumen in variable proportion, together with some few leucocytes and red blood-corpuscles, and they are ascribed to mechanical hyperæmia, or to inflammation of a low grade; whilst the *exudations*, containing solid elements, *e. g.*, white blood-corpuscles in any quantity, and fibrin—or the materials capable of readily forming it—and, possibly, other organic products, are designated as "inflammatory," and ascribed to a more positive condition of inflammation.

In all cases these exudations are derived from the blood. An apparent exception is the cell germination that takes place so actively outside of the vessels, either of wandering cells or tissue cells, when stimulated by the direct contact of the capillary exudation. As a general rule, afflux of blood causes capillary distension, and, as a result, exudation through the capillary walls follows—a sweating—as the term implies; or, capillary distension from mechanical obstruction, as from a tight bandage, may be followed by a similar result. A collection of fluid in the meshes of the subcutaneous connective tissue constitutes *œdema;* and this fluid may be thin and watery, or rich in albumen.

Passive exudation through the walls of capillaries altered by malnutrition, as in convalescence from acute disease, will be reabsorbed by the lymphatics as the quality and tone of the vascular walls is restored; but the more *active exudation* through over-distended capillaries whose walls are altered by acute or persistent inflammation, will be more likely to go on to tissue formation, or, this failing, to suppuration. Organic chemistry has not as yet taught us enough concerning the organic constituents of these so-called inflammatory exudations to aid us in classifying them. The microscope has done something more; but our knowledge of the subject, for practical purposes, is far from complete. Clinical illustrations of their different forms may serve to explain certain symptoms and phases of the inflammatory condition.

The cardinal symptom of *swelling* is for the most part due to exudation. Under some circumstances, as, for example, after certain poisoned wounds, it is so rapid and extensive as to suggest that, if not purely serous, the poison must have suddenly altered the walls of the capillary bloodvessels as well as their contents. And yet the sudden and rapid swelling that sometimes follows the sting of a wasp, or the bite of a rattlesnake, may subside in a limited time and leave scarcely a trace. The swelling of the leg that takes place during the growth of a popliteal aneurism, is at first, apparently, simple œdema; but the leg subsequently becomes warmer than natural, and brawny to the feel, as though the exudation were becoming organized; and, in view of the slow recovery from this condition after the aneurism has been cured, as though by atrophy of the new tissue, it would seem that this apparently inflammatory condition has really been caused by the blood-stagnation. A similar brawny thickening of the legs occasionally follows the œdema due to hepatic disease, to obesity, to failure of the heart's action from age; and it sometimes accompanies varicose ulcers. Although mainly the result of mechanical hyperæmia, the swelling is often attended by increase of heat.

Under the name of *acute œdema*, Sir B. C. Brodie described a rapid swelling of the scrotum by infiltration of its lax subcutaneous connective tissue, causing gangrene of the integument, apparently by cutting off its blood-supply through over-stretching of its nutritive vessels. This was probably an acute necrosis of the connective substance, such as occurs in phlegmonous erysipelas. The fluid of an ordinary *hydrocele* is slightly viscid and sticky, of a light amber color, with an alkaline reaction. It is so rich in albumen that the addition of nitric acid will often convert the fluid into a solid mass, by neutralizing the soda which keeps the albumen in a fluid state.

Serous exudation occurs more readily in localities where the bloodvessels are surrounded by lax connective tissue. Hence the danger of infiltration of the thyro-arytenoid folds, and consequently of obstruction of the glottis—an example of the œdema always present in a greater or less degree in the meshes of the connective tissue of the outlying area surrounding a focus of inflammation. When confined to a limited surface, this form of exudation constitutes a valuable indication of the presence of an abscess beneath. It has been

called *collateral œdema*, and its fluid contains white cells and fibrogenous material.

Of these so-called serous exudations, it is stated by a recent authority[1] that the assertion that they contain only dissolved albumen "has been assumed, rather than chemically demonstrated. In reality, these fluids," exuded mostly under the influence of obstructive hyperæmia, or a low grade of inflammation, "almost always contain variable quantities of fibrogenous matter, of fibrin, or of mucus, according to the part affected." In this way we explain the occasional coagulation of the exudation following a blister, and the coloration sometimes caused by the presence of red corpuscles or of their coloring matter in a state of solution. The free watery discharge from the nose after "taking cold," by which the congested Schneiderian membrane relieves itself, often leaves the handkerchief stiff as if it had been starched.

The distended bloodvessels in inflammation not unfrequently relieve themselves entirely and finally by exudation, thus bringing the crisis to a close.

In a case of abdominal dropsy, which followed peritonitis after a miscarriage, the patient experienced a complete cure by tapping. She returned some months later with no fluid whatever in the peritoneal cavity; but there was a hernial protrusion at each femoral opening, and a third at the umbilicus.

In this case the peritonitis had evidently relieved itself—had "terminated," technically—by free serous exudation. In an ordinary gum-boil, the intense pain usually ceases as soon as the external swelling begins.

The quantity of the apparently watery exudation which escapes from the cut surfaces after an amputation, subsequent to the arrest of hemorrhage, is very considerable; after an amputation at the hip-joint, it has been estimated at from a pint to twenty ounces. It is generally tinged by dissolved blood-clot, and often stains and saturates the dressings so as to suggest the idea of hemorrhage. It is not for us to determine the source of the fibrin which constitutes so large a proportion of the coagulum deposited by this exudation. Organic chemistry has left this question still in the region of theory. It evidently approaches in its nature, or is identical with, what is styled by a recent authority[2] "the well-known inflammatory effusion," and is derived directly from the *liquor sanguinis*, to which it approaches in quality. This exudation, according to the same authority, contains "more albumen, phosphates, and carbonates" than serous exudations, and "has a much greater tendency to coagulate, due to the white corpuscles it contains;" forming thus a hot-bed or compost admirably suited for promoting cell germination, and for furnishing nutritive materials for young cells. The white corpuscles are regarded as emigrants or wandering cells which have escaped through the capillary walls. It has been observed that the exudation in inflammation which occurs early is always more fluid; at a later period it contains more cells.

The exudation in healthy or constructive inflammation, generally called *plastic* or *coagulable lymph*, which makes its appearance on the surface of a recent wound, or in the form of swelling around an inflammatory focus, is, as has just been stated, a bland and unirritating product of the nutritive machinery; its obvious use is to aid in forming a growth of new tissue for a reparative purpose. This purpose may find its result in the organization of cicatricial tissue, whereby a breach of continuity is healed; or in forming a limiting barrier to suppuration, which is always, in some degree, destructive;

[1] Cornil and Ranvier, Manual of Pathological Histology. Philadelphia, 1880.
[2] Green, ut supra.

or in aiding the separation of parts which have lost their vitality. In the attainment of these objects, the organization of a new growth of tissue is indispensable. When this tendency to organization is opposed by any obstacle, as where the cicatrization of a wound is prevented by the presence, for example, of a sequestrum of bone not yet separated, then the new growth remains indefinitely, or until the obstacle is removed, in the inchoate stage of *indifferent* or *granulation tissue*, and the redundant supply of exudative material is wasted in the form of *pus*.

There are varieties of inflammatory exudation closely allied to plastic or coagulable lymph, if not identical with it, and equally remarkable for their prompt tendency to organization, which are encountered especially in wounds and inflammations of serous membranes. The apposition of serous surfaces after injury is immediately followed, under favorable circumstances, by *adhesive inflammation;* and this means the organization, in plastic lymph, of a new growth of tissue which forms a bond of union between them. The "false membranes," so often found in the shape of abnormal bands of tissue binding together free surfaces of the pleura or of the peritoneum, have the same origin. They are the result of constructive inflammation following some injury, which, but for the binding and restraining influence of the new formation, would have gone on to the destructive phase, that is, to pus formation. In still more purely fibrinous exudations, their coagulation is said to take place suddenly and in successive layers.[1] The dense, bulky, sometimes stratified layers of fibrous tissue in which the testis is found enveloped after an old injury, are sometimes organized blood-clots within the cavity of the tunica vaginalis, and sometimes organized exudation from the surface of this membrane, by which it has become enormously thickened.

In a man of 35, whose testicle had been suspected to be the seat of malignant disease, but who had a previous history of contusion and consequent hæmatocele, a healthy testicle was found in a cavity lined by what seemed to be tunica vaginalis, also apparently healthy, and containing no appreciable fluid, the walls of which were an inch in thickness throughout its whole extent, and resembled cicatricial tissue.

A similar mechanism has been assigned as an explanation for the appearances often presented in the interior of the sac of a cured aneurism. They are described by Robin[2] as "*caillots actifs fibrineux*," in contradistinction to the soft spongy coagula which are liable to form in aneurisms, and which possess no curative value.

Inflammatory exudations from the free surfaces of mucous membranes are said by Cornil and Ranvier[3] to contain mucus, and a substance called *mucin* which appears in the form of filaments, insoluble in acetic acid, and which "may form thick layers upon the surface of articular cartilages, notably in the case of white swellings."

What is called *croupous exudation*, as met with on the surface of mucous membranes in the air passages, in the bladder, and, somewhat rarely, in the intestines, is said to consist of filaments of fibrin, and sometimes of mucin, felted together with pus corpuscles and epithelial cells—according to the region—in their interstices. The false membranes of true croup, according to the best authority,[4] are not composed of true fibrin, but of altered and overgrown epithelial cells. Fibrin is present in the exudation from an inflamed mucous membrane only when its epithelium has been partially or completely destroyed.[5]

[1] Cornil and Ranvier, op. cit., p. 64. Philadelphia, 1880.
[2] Leçons sur les humeurs.
[3] Ut supra.
[4] E. Wagner, Manual of General Pathology. New York, 1876.
[5] Weigert, Article on Inflammation. Real-encyclopædie der gesammten Heilkunde, Band i. S. 642.

Plastic or Coagulable Lymph.

To return to the well-known inflammatory effusion which exudes from recently divided living surfaces, and deposits upon them the plastic or coagulable lymph by the organization of which their union is effected, this form of exudation, and the steps by which it undergoes the organizing process, are worthy of careful study. It is the characteristic product of the "adhesive" inflammation of Hunter, the normal type of the true, healthy, constructive process. Hunter describes the aspect presented by the pale jelly-like coagulable lymph as it appeared to his unaided eye upon an exposed surface of bone; he could easily have wiped it away, but did not; the next day, to his surprise, it had become pinkish in color, and bled when touched by the probe. It had become organized. The mechanism of this curious change—one of the changes which constitute the condition of inflammation: that is, the organization of plastic lymph, which histology and embryology have since rendered plain to us—it is the surgeon's duty to supervise; and to do this intelligently he must be familiar with it. Hunter wisely withheld his hand and watched the process with the eye of genius. At the end of another century, with the advantage of the microscope, we enjoy the privilege of seeing more clearly the minute appearances which attend the organization of plastic lymph, and can recognize with certainty what Hunter only assumed.

The substance of coagulable or plastic lymph affords by its chemico-vital constituents the best possible pabulum for cell germination and sustenance, and the leucocytes or white corpuscles already present in it begin, at once, to germinate. In a few hours after the receipt of a wound, the process of cell germination has converted the jelly-like material deposited upon its surface into a mass of granular cells, all of the same size, and so numerous as to touch each other on all sides, leaving only minute angular interspaces filled with intercellular substance. These granular cells are minute spherical masses of protoplasm, called by Huxley "embryonic" cells. He gives them this name because they are the first formed and most constant features that make their appearance in the jelly-like substance—plastic lymph, it might be called—that constitutes the human embryo when it first becomes manifest under a magnifying power. They are almost if not quite identical with white blood corpuscles, with lymph corpuscles, with young pus cells, with young epithelium, with so-called granulation cells, and with young connective tissue corpuscles; and to all these cells, undistinguishable from each other in their earlier stages by any means at present under our command, the common appellation of *leucocytes* or *indifferent cells* is applied by histologists.

And now, as soon as the plastic lymph has been thus converted by the germinal power into a mass of living cells, another strange phenomenon takes place: a minute stream of cells, differing in appearance from those just described, may be seen coursing its way through the crowd of leucocytes, which seem to flatten out and make walls, apparently to keep the slender current within bounds; and this tiny stream of pinkish yellow cells, curving upon itself, assumes, forthwith, the outline of a loop. It is, in fact, a newly formed capillary, containing red blood-corpuscles, which are readily distinguishable as such by their faint color, and their characteristic shape—that of flattened bi-concave disks. The new capillary loops shoot into the cell mass from the surfaces of the recently divided tissue, projected, as it were, from its over-distended capillaries by a process of budding and growth of new vessels, or by simple rupture and "channelling." However formed, they shortly constitute myriads of delicate connecting threads running into the mass of recently germinated cells which, thus furnished with a blood supply, begin

to undergo another change. The cells, heretofore "indifferent" embryonic corpuscles, begin to alter their aspect, and to develop into connective-tissue cells; the intercellular substance undergoes the process called fibrillation; and thus the embryonic substance becomes converted into *young connective tissue.*

The office of the newly-formed tissue now becomes apparent: it is truly connective, for, having filled the breach, it straightway draws and binds together the opposite sides of the wound, and thenceforward takes the name of *cicatricial* tissue. Thus, the adhesive, cement-like material furnished by the inflammatory exudation becomes organized into new tissue that forms a bond of union by which a breach of continuity is healed.

This is the mechanism by which constructive inflammation fulfils its reparative office in its most simple and typical phase. The stages of the process are appreciable by the naked eye, and at the bedside, by the symptoms already detailed, which vary in intensity according to the size and depth of the wound. The result constitutes *union by the first intention.*

The cicatricial bond becomes invested with epidermis by the same process of cell growth and development. At first the scar is redder than the neighboring integument, in consequence of the larger proportion of vessels carrying the red blood necessary for its organization and growth. But afterwards its succulence diminishes; the capillaries, no longer required, shrink or disappear; so that the cicatrix diminishes in bulk, and becomes paler in color, forming, after the primary union of an incised wound, a simple white line, in many cases scarcely visible.

In the case of an abrasion, or a surface wound of limited extent, the exuding plastic lymph dries upon the raw surface when it is left at rest and exposed to the dessicating action of the air, and covers it with a crust. By this mechanism, which is the common mode by which Nature cures the slighter wounds of animals, a tough and somewhat flexible scab is formed, which protects and seals the raw surface from external contact. Beneath this natural dressing, if undisturbed, the breach of continuity is repaired very perfectly by the organization of plastic lymph. The dried scab, in due time, falls spontaneously, revealing a smooth, slightly reddish surface invested with epidermis which, subsequently, becomes paler in color, and often scarcely distinguishable. This is a mode of repair in which the symptoms which ordinarily attend inflammation are usually very slight, and often seem to be entirely absent. It is called *healing under a scab*, and is, in fact, Nature's favorite method of cure, and should always be promoted when circumstances are favorable.

In superficial wounds of *mucous surfaces*, a similar prompt result of constructive inflammation is accomplished under the sheathing protection of the mucous secretions. Wounds and lacerations of *internal organs* often leave cicatrices behind them, discovered on post-mortem examination, as the only evidence of their previous existence. A rupture of the *tendo Achillis*, or a simple fracture of *bone*, undergoes repair by the process of tissue formation just described as "healing under a scab." The part played here by the leucocytes which germinate in the plastic lymph justifies the title conferred upon them of "indifferent" cells, for they develop with equal facility into tendinous or bony substance, as into connective tissue.

All these examples of the inflammatory process, usually spoken of as "adhesive," "constructive," or "reparative" inflammation, representing the mode in which are cured the great multitude of simple lesions which never come under the cognizance of the surgeon, serve to illustrate the natural healing powers possessed by the organism. It is only when this benign process, which we have described as simply an unusual effort on the part of the ordinary local nutritive apparatus, is interrupted or interfered with in any way, that

we are liable to encounter the symptoms of the more serious forms of inflammation which have been designated as *destructive*. The more common sources of interruption to the normal process of repair have been already enumerated, under the title, heretofore in common use, of "predisposing" and "exciting causes of inflammation." Now it is obvious that these expressions are strictly correct only in the limited sense which regards the *causes* of inflammation as obstacles to the continuance or completion of a normal process, or as opening the way for, and favoring, as it were, the bad consequences which necessarily follow stoppage or interruption of the nutritive machinery of a part, or its failure to repair an injury in a natural way. In any other sense, a conclusion could be assumed as logical that these causes provoke destructive inflammation as an essential and an aggressive disease, a doctrine which in the early part of this article was distinctly denied.

Destructive Inflammation. Pus Formation.

In accordance with this view, the symptoms of destructive inflammation, which we have next to consider, are to be regarded as the consequences of some cause or causes which, by their influence upon the organism, have had the effect of interrupting or impairing normal local nutritive action, in connection with the series of changes following injury. This doctrine will be illustrated by the study of *suppuration*, or *pus formation*, the most common and important of the changes liable to follow injury. Suppuration is properly treated of as a symptom of inflammation of the *destructive* sort, because, although commonly associated with the mode of healing by granulation and suppuration, known as "healing by the second intention," it never takes place without a distinct and positive loss of substance. Healing by the adhesive process—"by the first intention"—does not necessarily involve any, or an almost imperceptible, textural loss; but whenever pus is formed, there is at least an equivalent furnished in nutritive material, or in tissue already existing.

Suppuration and Granulation.—To describe the mode of pus formation in its most common aspect, let us recur to the condition of an open wound, the surface of which has become glazed by a deposit of plastic lymph, but in which from loss of substance, or the presence of foreign material in the wound, its surfaces cannot be brought together, in accurate contact, so as to secure union by primary adhesion. Here the object of the exaggerated effort on the part of the local nutritive apparatus to repair the lesion in the most simple and effective way, is rendered unattainable; the purpose for which the inflammatory exudation has been poured out, is baulked. But Nature has other resources at command by which the end can be reached; not so promptly and readily, with more delay and expense, but still repair of the injury can be accomplished. Her next effort towards this end is, after the delay of a day or two, and with a certain amount of local soreness and swelling, and more or less general disturbance or distress, to generate a red velvety surface upon the wound, and clothe it with a bland, cream-like yellowish fluid. Under these new conditions, if circumstances are favorable, the wound goes on to heal, in the manner to be described. The soft red surface is *coagulable lymph* which has become organized into *indifferent* or *embryonic* tissue—henceforward to be spoken of as "*granulation tissue*;" and the yellowish bland fluid is pus. The nature and uses of these "products of inflammation" we have next to examine.

Although generated at the expense of some local and general disturbance to the organism, it is to be noted that these substances obviously have a pur-

pose, which is reparative, in accordance with which they are physically and chemically soft and bland; and that they are the product of the nutritive machinery of the injured part by a natural process analogous to embryonic growth and development. Granulation tissue, with the clinical aspects of which the surgeon must be, of necessity, familiar, consists of embryonic cells and a network of capillary loops which convey to it a steady supply of nutritive material from the blood. It is equipped, so to speak, for growth and development into a higher form of tissue, *e. g.*, tissue of cicatrix; but when this purpose is prevented, or when it becomes unattainable, the neoplasm is capable of supporting itself in an inchoate condition, as simple granulation tissue, for an indefinite time—of which we have an illustration in the walls of an old sinus. It is well to notice that, with this power of endurance, the original purpose manifest in the organization of this curious substance is never lost sight of; it is ready to take on development into a higher form of tissue whenever favorable conditions arise.

In its physical aspects, granulation substance has a pinkish color, variable in tint according to the quality of the blood circulating in its vessels, and is jelly-like in consistence, with a certain degree of smoothness and firmness to the touch. Its surface, when healthy, is covered with small conical eminences called granulations, not entirely uniform in size, in which, by the aid of a pocket lens, minute vessels can be distinguished. The latter are so near the surface that a slight touch of probe or needle brings a drop of blood. Yellow pus is seen in the depressions between the eminences. These vary a good deal in size and shape as well as in color, and, inasmuch as their aspect affords an unfailing index of healthy healing power, and as they are found on all healing surfaces, these variations are worthy of close observation.

When there is a lack of vigor in the tendency to grow into cicatricial tissue, the granulations are large and translucent, and the pus between them is pale and thin. When there is excess of inflammatory action, as when the part has been subjected to motion involving friction, or to irritating dressings, they become abnormally small, and their color is vividly red. Subsequently, under the persistent action of the same causes, the granulations may disappear at points, showing grayish spots in which they have died, or smooth patches in which they have ceased to grow. Usually, healthy granulations are not sensitive to the touch, for, although full of bloodvessels, they contain, as yet, no nervous filaments, although the contrary is asserted by Robin and others; it is undoubtedly true that in certain abnormal conditions they become exquisitely painful. Individual granulations vary in size and shape, even upon the same surface. They are sometimes larger at the apex than at the base, and occasionally will be found cleft at their summits like a cauliflower.

When cicatrization is about to take place, and its consummation is prevented in any way, granulations in some cases tend to increase in size, and to become overgrown: as around a seton, a group of ligatures, or a drainage tube; or in a wound involving the sheath of a tendon. Under these circumstances, a number of overgrown granulations may coalesce and form a pouting mass, overhanging the edges of a wound, and constituting what is known popularly as "proud flesh." These redundant granulations are generally more pallid and flabby than those of healthy type, and their presence always indicates that some cause is obstructing the beginning of cicatrization.

A surface of granulations undoubtedly possesses a considerable power of absorbing soluble substances brought into contact with it. This has been already asserted in connection with the capacity of granulations for absorbing blood poisons. If a small fragment of iodine enveloped in cotton be placed upon a granulating wound under a watch-glass, and covered in carefully, in a very short time chemical reagents will reveal the presence of iodine in the

urine.[1] Where an animal poison, or virus, as, for example, that of hospital gangrene, or of the contagious venereal ulcer known as chancroid, has been brought to bear upon a granulating wound, or ulcer, then the whole process of healing by granulation is blighted. The granulations themselves melt away, or die, and their substratum of tissue is converted into what is called a *slough*, which is a layer of dead tissue—a moist eschar. When somatic death takes place during the healing of an open wound, its granulating surface will be found, on post-mortem inspection, to have mainly disappeared. It is replaced by the glazed surfaces of the original wound. When the heart ceases to beat, and their blood supply is thereby cut off, the granulation cells shrivel and dry up, or melt away by liquefaction. The latter is the most usual mode of death of the leucocyte, and of all organic cells.

Thus far we have considered the physical aspects of granulation tissue, but little has been said concerning the formation and discharge of pus, which constitutes so prominent a feature in the healing of open wounds. A flow of pus goes on uninterruptedly from all parts of the surface of every open wound during healthy healing, as a part of the normal process. The first appearance of pus in an open wound marks the successful organization of the plastic lymph, the first stage in healing; it coincides with the heat and tension of the wound, and the febrile movement affecting the whole organism which has been already mentioned. As soon as suppuration has fairly made its appearance, the swelling, tension, and heat of the wound are sensibly relieved, and the increased temperature of the body and frequency of the pulse, if present, generally subside. After an amputation, where the wound has remained open, and its progress has been favorable, the soft connective and muscular tissues are covered with granulations in from three days to a week; but the harder white fibrous aponeuroses and the tendons require more than double this time; and the bone may remain bare and white for three weeks or longer. But, unless there is a dead portion to be cast off, even these unpromising-looking parts become in time invested with a rosy film of organized lymph, and now the whole surface of the wound presents an uniform expanse of granulations.

If the granulations are healthy, this is the propitious moment for attempting union by "*secondary adhesion.*" It is a property of granulating surfaces to adhere promptly and permanently if brought together accurately and held in quiet contact; and this property of healthy granulations is taken advantage of by the surgeon in many ways in order to expedite healing. Now, when secondary adhesion is successfully attained thus instantaneously, what, in this event, becomes of the discharge of pus? In order to answer this question satisfactorily we must first study somewhat more closely the intimate nature of pus, and learn what is to be known concerning its source and its significance.

Physical Qualities of Pus.—In its most usual form, healthy pus is a cream-like fluid of a yellowish-white color, tending sometimes to assume a pale greenish tint; it has a mawkish, faintly animal odor; a slightly saltish and rather sweet taste; an unctuous, soapy feel; no viscosity or stringiness; and an alkaline reaction. Pus is constantly presenting variations from these normal characteristics according to the circumstances under which it is generated, the tissues at the expense of which it is produced, and its freshness or age. It manifests little disposition to putrefaction, even at the temperature of the body, as long as the air has no access to it; and, when removed from

[1] Legouest. Dictionnaire Encyclopédique. Art. "Cicatrice."

the body and exposed at an ordinary temperature, it is rather slow to undergo change.

When allowed to stand quietly for some hours, pus gradually separates into two portions: one, solid, which, under the influence of gravity, sinks to the bottom of the vessel; and another, liquid, and lighter in color, which floats. The solid portion of fresh pus consists almost entirely of leucocytes, which are here called *pus-corpuscles;* its liquid portion is a serous fluid known as *liquor puris.* In normal pus of average quality, its solid portion constitutes about twenty-five per cent. of the whole; three-quarters of its bulk being, therefore, liquor puris. But this proportion may vary greatly: in most cases, by diminution in quantity of the corpuscles. Thus, in the thin, serous, watery pus that comes from an open wound on the eve of healing—when it usually presents this quality—or in that furnished by an indolent ulcer, the proportion of corpuscles may sink as low as two or three per cent.; whilst in the thick unctuous discharge from a healthy granulating wound, or an acute abscess, it may rise as high as twenty-nine per cent.[1]

The presence of pus of good consistence—the "laudable" pus of the older surgeons—indicates the existence of active reparative power. Thin pus means just the contrary: either that the healing process has reached a natural termination—a cicatrix being about to close in the suppurating surface—or that its healthy progress is otherwise interfered with or suspended. When pus is formed under pressure, as in the antrum of the upper jaw, or in abscess of bone, it may present the aspect of a yellowish, solid, *cheesy* mass, the compressed pus-cells showing, under a magnifying power, an angular outline. But they will swell in water, and the addition of acetic acid will bring out the characteristic nuclei. Solid pus has been mistaken for tubercular deposit. As to variations in color, pus sometimes presents a deep yellow or orange tint from bile, or, in rare cases, on dressings long unchanged, it shows a blue color, which is caused by the growth of a minute fungus or mould. All the other tints of pus come from the coloring matter of the blood—hæmatoidine.

Anatomical Characteristics of Pus.—When we investigate the *anatomical characteristics of pus*, after separating its solid constituents from the serum, we find that more than nine-tenths of the former consist of leucocytes or young pus-cells. These latter, in freshly formed pus, present, under a moderate magnifying power (250 diameters), the granular aspect, and also the peculiar amœboid movements, of vigorous young healthy leucocytes. In pus which has been collecting in an abscess for several days, or which has been discharged from the body for a few hours, these movements indicative of life are no longer to be seen. Under these circumstances, the pus-corpuscles present themselves as cells with from two to five nuclei, most generally three, and these form a cluster resembling a clover leaf. This is considered and pictured as the most characteristic form of the pus-corpuscle. But, whenever the pus-corpuscle presents this aspect, it is no longer capable of amœboid movements—it is dead. A film, constituting a sort of cell-wall, has formed around its outer surface; it is uniformly round. When subjected to the action of dilute acetic acid, it dissolves—all except the outer film or cell-wall, and the central trefoil-shaped nucleiform mass.

These two varieties of pus-cells, living and dead, are often seen mingled together in various proportions in an ordinary specimen of pus. In pus which has been formed for some time, and confined in contact with the tissues, there are also found larger corpuscles, overgrown, as it were, and stuffed with granules of fatty matter in addition to their nuclei; these are

[1] Robin, ut supra.

simply obese pus-cells which have been overtaken by fatty degeneration—one of the diseases to which pus-cells are liable. Minute drops of free oily substance, also, as well as granular *débris*, are almost always present in pus, derived from the breaking down of the overgrown granular corpuscles just mentioned, or from neighboring adipose tissue. More rarely the delicate needle-shaped crystals of the fatty acids—the margaric and stearic—may be detected. It is the presence of this small amount of fatty matter in pus that gives it the odor, when boiled, of boiled milk. A certain portion of this fatty matter enters into combination with the salts of potassium and sodium which are always present in the serum of pus; and this explains its soapy feel. Cholesterine, recognizable by its broad rhomboidal crystalline plates, is also sometimes seen in pus, especially in that from the testes, broad ligaments, and ovaries, and from pelvic and psoas abscesses.

Amongst the accidental elements sometimes recognized in pus are vibrios and bacteria. Here, these organisms have usually this simple signification, and no other, namely, that the pus in which they are found is about entering into decomposition; that its vital quality is at a low ebb, and that chemical forces are in the ascendant. Red blood-globules are constantly met with intermingled with the cells of pus; they come from the rupture of capillary vessels, from inflammatory over-distension. The admixture, in larger proportion, of both blood and oily matter with pus, is often apparent to the naked eye, as when the contents of an abscess have been evacuated by incision through vascular and fatty tissues. In pus which has formed in contact with diseased bone, minute granules of bone-earth are sometimes found. Under all circumstances, the *débris* of the tissue at the expense of which pus is formed, is liable to be present in it, in larger or smaller masses.

The Liquid Portion of Pus.—Liquor puris, when separated from the solid materials of pus by careful filtration, is a clear, slightly alkaline, albuminous liquid containing no solid particles whatever. Its alkaline reaction is due to the presence of salts of sodium with excess of base; it also contains chloride of sodium, and the phosphates of sodium, lime, and magnesium—more of the two latter when the pus has formed in contact with bone. The addition of nitric acid will, therefore, always cause a precipitate of albumen from the filtered serum of pus. In decomposition, or whenever ammonia is present, the well-known large prisms of the triple phosphate of ammonium and magnesium can be detected in pus. They are generally present in the dried pus that collects about a wound. In the exceptional cases in which pus reddens litmus paper, there is rancidity in consequence of the generation of butyric and other fatty acids. When *liquor potassæ* or *aqua ammoniæ* is added in a very moderate proportion to pus in a test-tube, and the two substances are shaken together, a curious semi-solid translucent mass results, which has the aspect and consistence of dense mucus. The pus-cells are dissolved by the alkali, which also reacts upon the albuminous compound in the liquor puris. The slimy substance that forms when the parts around an open wound are washed with soap and water, is a result of this peculiar reaction of pus with the alkali of the soap. It also explains the characteristic ropy mucoid discharge from the bladder, in cystitis, whenever ammonia is set free in the urine.

The Sources of Pus.—We have next to consider the source of pus. The first question that presents itself is this: What is the force that brings leucocytes to the surface of a granulating wound to be discharged thence in the form of pus? This force seems to be found in the *liquid exudation*, the supply of which from the capillaries, both newly formed and old, is copious and continuous, until arrested by the cicatrization of the wound. The afflux of blood

inaugurated by the injury, and impelled by the same force that carries the normal nutritive supply to the tissues, only somewhat exaggerated, continues to relieve itself by exudation, until the necessity for the increased nutritive supply ceases. This constant supply of nutritive material for the growing granulation-cells is in excess of the demand. After percolating through the mass of granulation tissue, the excess of liquid exudation reaches the granulating surface, carrying out with it a certain proportion of the leucocytes amongst which it has passed, which seem also to be in excess of the demand, and thus, finally, makes its appearance upon the granulating surface, as pus. A simple experiment shows that this is not entirely theory, but, in some degree, at least, demonstrable fact. If the surface of a granulating sore be carefully dried off by a mop of absorbent cotton, and then subjected to the action of an irritant, that is, if a little common salt be sprinkled upon it, or a hot cautery iron be brought almost in contact with it, myriads of minute drops will be seen to exude, like sweat, from the previously dried surface. Now, if a drop of this fluid be placed under a microscope, it will be found to contain leucocytes in numbers; in fact, it is pus.[1]

Under all the various circumstances, therefore, in which pus is formed in the body, in all localities—whether on the surface of mucous or serous membranes, or in the depths of the tissues—these, as in a granulating wound, would seem to be the factors which contribute to its formation: liquid exudation from capillary vessels, and leucocytes. A surface of granulation tissue is, by no means, the only source of pus; it may form, under certain conditions, in any part of the body. It is meant by this statement, that no previously formed granulating surface or so-called "pyogenic membrane" is necessary for the formation of pus—a doctrine which was formerly in vogue.

The first phenomenon that attends pus production is liquid exudation; the next, cell germination. It may be understood, now, why Robin designates pus as an "accidental secretion;" and why Billroth insists upon calling it "liquid neoplasm." On the other hand, it is to be kept in mind that granulations may form, grow, and develop into connective or cicatricial tissue—as in primary union, or between the ends of subcutaneously divided tendons—without the formation of a drop of pus. Its presence is not, therefore, necessary for the accomplishment of the process of repair of injury, which is the main purpose of inflammation.

To comprehend the sources of pus, as well as the causes and modes of its formation, it is desirable to examine a little more closely the phenomena which attend its production elsewhere than in external wounds: in abscess, for example, and on serous and mucous membranes. The subject of abscess will be treated formally in another article; it is referred to here in order to illustrate the nature and mode of formation of pus as one of the best known products of inflammation, and to enable us to discuss more intelligently the question as to its uses.

An *abscess* is a collection of pus in the substance of the tissues. An *acute abscess* affords an excellent example of a local inflammation, presenting all the cardinal symptoms and features of this condition, and usually "terminating," to employ the classical expression, in suppuration. Why, and how, is pus formed in the substance of the tissues, are the questions which concern us. Judging from clinical observation, the reason why an abscess forms is to get rid of, or throw off, a dead or altered portion of tissue, or some foreign substance, which has proved noxious or irritating to the organism. Its purpose, in other words, seems to be eliminatory. We have already remarked that

[1] Cornil and Ranvier, ut supra.

pus from the vicinity of diseased bone is liable to contain gritty particles of bone-earth. The core of an ordinary *boil*, which is an example of an acute abscess, consists of a little mass of filaments of yellow elastic tissue, the remains of a portion of connective substance which for some cause has died and become liquefied—all but the more indestructible yellow elastic element. This, acting as a foreign body, like a splinter, has proved a local irritant, and caused festering, or pus formation, apparently to secure its escape by being floated out when, in its natural course, the contents of the abscess are discharged. After the escape of its core, the boil promptly gets well. The little flocculent curdy masses often seen escaping from abscesses with the pus, especially from those of scrofulous or tuberculous subjects, where the general condition of the patient is poor, and the pus, consequently, thin and watery, are either little aggregations of pus-cells, or altered tissue—sometimes tubercular matter—little cores, in short, as of boils. The little abscess, or pustule, that forms in the substance of the skin in *smallpox*, has for its purpose the elimination of the disk-like slough of true skin which has been killed by the variolous poison in its effort to escape through the emunctories of the integument. The depression or "pit" that follows marks the loss of substance.

The circumstance of textural death, or of change in chemical or vital qualities under the multifarious unfavorable conditions which affect the blood and nervous centres, so as to disturb the equable interchange of material which belongs to normal nutrition, would seem to be a fertile cause of abscess. The influence of disturbed innervation as a cause of abscess is exemplified in the occurrence of stye from fatigue of the eyes, and in the pustules of acne, symptomatic of sexual abnormity, which disappear after marriage.

As to the mode in which pus formation takes place in the substance of the tissues, as in the occurrence of an abscess, it is as follows: (1) The exciting cause, whether textural injury from traumatism, or textural degeneration from local disturbance of nutrition begetting a source of irritation, provokes an afflux of blood to the centre of excitement. (2) The distended capillaries give forth liquid exudation, which coagulates, at the centre of excitement, into plastic lymph, distending the meshes of the immediately surrounding tissues with a more serous fluid. (3) In the plastic lymph cell, proliferation begins, and goes on to the formation of leucocytes, which, not being favorably situated for growth and development into tissue, accumulate as pus. The pus, as it collects, forms a cavity for itself, as we shall see shortly, and the result is an abscess. These phenomena occur, most generally, in moderately rapid succession, and are attended by pain, heat, swelling, and redness—the latter not always showing itself upon the surface; evidences of constitutional disturbance may also be present, most frequently in the shape of fever.

With these attendant symptoms the abscess is *acute;* but, as in *cold abscess*, they may all be absent, with the exception of the symptom of swelling, which is caused by the accumulation of pus. The formation of a cold abscess in many cases resembles more the growth of a tumor than a result of inflammation; nevertheless the mechanism of the pus formation is identical with that already described, only the phenomena succeed each other more slowly. Thus, in a psoas or lumbar abscess, some local degeneration of bony or white fibrous tissue may serve as its starting point, and, as in the former instance, afflux of blood is provoked, and the result is exudation and cell germination. These are, in fact, the essential and peculiar changes which constitute inflammation; and they are more constant than the cardinal symptoms they occasion, on which we mainly rely for its diagnosis. It is profitable to notice how closely the pathological changes which constitute inflammation approach, in some of their phases, to those which attend the growth of tumors; and

how both of these series of changes are only modifications of the normal nutritive process as seen in embryonic growth development.

The formation of pus on the surface of a *serous* or *mucous membrane*, as in empyema, or urethritis, is attended by a less serious vital effort than its formation in a wound, or in an abscess; for leucocytes, it must be remembered, already exist as a part of the secretion of these membranes in a state of health, and the conversion of these secretions into pus involves little more than increased activity in cell germination. The exudation constantly taking place from the network of capillaries which underlies every serous and mucous membrane, furnishes nourishment for the epithelium which is being constantly renewed on their free surfaces. Now, if the equilibrium of health be disturbed, say in consequence of prolonged chilling, as in pleurisy, or through the contact of a poison, as in gonorrhœa, the injury thus offered creates a fluxion of blood to the capillaries of the membrane, and a consequent incitement to an increase of cell proliferation. The result is increased discharge from the surface of the membrane, carrying off the excess of cell production; in other words, a discharge of pus. If young epithelial cells are identical with leucocytes, the induction of suppuration from a membrane involves nothing more than an increase of local nutritive activity. If they are different, and this question cannot be properly discussed here, then exfoliation of epithelium precedes pus formation, as asserted by Weigert[1] concerning fibrinous exudation from mucous surfaces, which, he asserts, is only possible after the epithelium has exfoliated.

Suppuration from membranes is attended usually, but not always, by pain, heat, increased redness, and tumefaction of the inflamed surface from exudation into the meshes of the underlying connective tissue. A return to a state of health is marked by a diminished fluxion of blood to the part, and consequent diminution in cell production. The cells resume their normal tendency to develop into epithelium; the pus, just in the same proportion, becomes thin and watery; and finally, as soon as the normal conditions are completely restored, it ceases. Notice that an application of dilute ammonia, a chemical irritant, would give rise to a similar succession of phenomena. In the experiments of Cornil and Ranvier, a solution of nitrate of silver thrown into the peritoneal cavity of the rat, was followed by exfoliation of epithelium and proliferation of leucocytes. On serous membranes, however, except where blood poisoning is present, or the injury is peculiar and sustained—as in intestinal perforation—increased activity in cell germination tends to prompt tissue formation, resulting in adhesion and the formation of false membranes, and not to pus production. We may observe that the analogy between the occurrence of a slow and insidious purulent collection filling the cavity of a pleura, and the equally deliberate formation of a cold abscess in the loins, is very obvious; and that both of these conditions are phases of inflammation. The causes which determine the difference between the manifestations of the inflammatory condition which we call *acute*, and the *chronic* changes of which these slow collections of pus are examples, are not clearly made out.

Phenomena attending Pus Formation in the Tissues.—We are now in a position to take cognizance of the phenomena which succeed the formation of pus in the substance of the tissues, and to estimate the propriety of calling them destructive. After this we shall be better able to form an opinion as to the uses of pus.

When pus is developed in the substance of the tissues in the manner just de-

[1] Ut supra.

scribed, these latter suffer both from its presence, and from its pressure; muscular fibres are broken down; those of connective tissue give way or are pushed aside; capillaries and nerves are first put upon the stretch, and then ruptured. The stretching of nervous filaments explains the sensation of aching that belongs to acute abscesses when forming, and their rupture, the sharper sudden darting pains that occur at intervals. In this manner, by steadily encroaching upon neighboring parts, pus forms a cavity for itself. The forces by which this end is accomplished are (1) the exaggerated afflux of blood to the part, indicated by the pulsatile character of the pain, and evidently derived directly from the heart's impulse; and (2) the irrepressible tendency to cell-germination provoked by the exudation which is being constantly sweated out through the walls of the distended capillaries. And here it is again worthy of notice how close a resemblance exists between the mode in which an abscess makes a place amongst the tissues for its growing bulk, and that followed by a round-celled sarcomatous tumor; a resemblance as close as that which is recognizable between the leucocytes of the growing abscess and the cells of the sarcoma, or between the fluctuation of the abscess and the feel, which so closely resembles fluctuation, of a soft cancerous tumor.

But pus, it is to be observed, may form where there are no capillaries, in the so-called non-vascular tissues, as between the layers of the epidermis, or in the substance of the cornea, or of cartilage. In regard to the minute changes which occur in these localities, histologists are not as yet entirely agreed. It may be stated in general terms that, when affected by inflammation, the non-vascular tissue tends to revert for the time to its embryonic condition. Clinically there is evidence, as regards cartilage, that, in wounds attended by loss of substance, the loss is substituted by connective tissue, often without suppuration. One of the best examples of this result is the *fibrous anchylosis* that follows the destruction of articular cartilages. They are replaced in many cases by connective tissue, binding together the ends of the bones, and at the same time preserving a limited degree of motion—converting, in short, a diarthrodial into a synarthrodial articulation.

Ulceration.

The phenomena which follow the formation of a cavity in the tissues by a collection of pus, are better considered now, for they still further illustrate the nature of this typical inflammatory process. Suppuration occurring beneath the surface may culminate in several ways, but the most common result, certainly of an acute abscess, is for the cavity, as it enlarges, to approach the external surface of the body, or that of one of its hollow viscera—simply because there is the least resistance in these directions; then by its steadily increasing pressure to cause, first, distension and stretching, and, in the next place, ulceration, of the tissues subjected to its action; and, finally, for the contents of the abscess to be discharged through the opening thus effected by the ulcerative process. In common language the abscess forms, and then bursts. This may be regarded as the natural termination of an abscess; and it is frequently imitated by art. The phenomenon of *ulceration*, by which the spontaneous discharge of an abscess is accomplished, has been commonly described as one of the "terminations" of inflammation, because it apparently brings this usually painful process to an end. After its contents have been thus evacuated, all the symptoms of the abscess are strikingly relieved, and, as a rule, it gets well forthwith. It is proper, therefore, to notice more particularly in what the process of ulceration consists.

As an abscess increases in size, a certain amount of redness makes its

appearance upon the surface which it is approaching. This surface redness is usually preceded by more or less œdema of the subcutaneous tissue, which is explained by the projection of the peripheral zone of serous exudation surrounding the central collection of pus. The advancing tumor next presents, at the centre of the surface redness, a more prominent and bulging point, where the color of the skin becomes purplish or livid. The skin is evidently also growing thinner, for the yellow tint of the pus soon becomes recognizable through it. In this stage an abscess is said to be *pointing*. Shortly the thinned integument gives way, and the pus exudes through the opening. The cause of this behavior of the skin is simply that the blood-vessels by which its nutritive supply is conveyed from beneath, have been stretched and obstructed by the pressure of the enlarging abscess, or have been actually ruptured by extreme stretching, so that the area of integument thus deprived of its blood-supply slowly dies. It dies by minute particles, or molecules, piecemeal; and the dead material is added to the contents of the abscess.

Under all possible circumstances, this *molecular death* is the essential feature of the process which we call ulceration; and its immediate cause is defect in the blood-supply. It is, therefore, a passive, not an active, process, brought about by agencies external to the parts that die. It is probable that insufficient supply of nervous influence aggravates the effect of the vascular deficiency; and, in some cases, a bad quality of the blood, or the blighting effect of a virus present in it, may, with slight additional cause, start and keep up the ulcerative process, as in some phases of syphilis and phagedæna. In any case, the relation of ulceration to inflammation is not necessarily that of effect and cause; for, although the two conditions are very commonly associated, and the same causes are competent to excite either or both of them simultaneously, nevertheless ulceration may take place without inflammation, as exemplified in the destruction caused by the slow and gradual pressure of an aortic aneurism upon the sternum or vertebral bodies. Pathologically, ulceration is more nearly allied to atrophy, and the retrogressive changes which follow insufficient nutrition; and, whenever the process takes place, it may be traced to one or more of the causes already detailed, without necessarily including inflammation. The relations between inflammation and ulceration resemble in many points the relations between inflammation and gangrene; they are incidental, rather than causative. They have been included in the series of changes following injury, with a somewhat loose estimate of their significance, and of their relations to inflammation; but they form no essential features of the inflammatory condition.

Gangrene.

It has been usual with surgical writers to speak of gangrene also as one of the "terminations" of inflammation. The sameness as to immediate causes renders the conclusions reached concerning ulceration applicable also to gangrene, and justifies the consideration of gangrene in its relations to inflammation more fully in this connection.

The term *gangrene* is applied to death of living tissues in *visible masses;* the term *ulceration*, to disintegration of tissue by the death, in detail, of *invisible molecules;* and the immediate cause of the local death in either case is deprivation of an adequate supply of nutritive material, without necessarily including the idea of inflammation.

The series of changes following injury, which are correctly regarded as constituting inflammation, do not include immediate death of the injured part.

But local death when it follows an injury after ever so short an interval, even when the series of changes has been very imperfectly inaugurated—perhaps not even begun—is usually credited to inflammation; whereas it should be, probably more correctly, ascribed to the injury. There are cases occurring constantly in which tissues are half killed, as, for example, in a crushed limb, and are unable to take part in the increased nutritive action necessitated by the reparative effort, even to the extent of separating dead from living parts. In the stasis that follows the first afflux of blood, these tissues perish, through lack of vital power in their vessels to carry on the circulation. This lack of power, through injury, may manifest itself at any stage of the constructive process; and, when it becomes manifest, sloughing and gangrene take place. In this sense inflammation may be said to terminate in gangrene. But it would convey a more correct idea of the pathological condition to say of such a result that the injury is too severe to be remedied by the limited power of repair with which the human organism is endowed. We may conclude from these considerations that neither ulceration, nor gangrene, can be properly styled a "termination" of inflammation. The results of the inflammatory condition to which this term is correctly applicable, will be enumerated hereafter.

The Significance of Suppuration.

Having now surveyed the different forms of suppuration, as it occurs in wounds in the process of healing by the second intention, on membranes, and in the substance of the tissues, and having examined, incidentally, the relations of ulceration and gangrene to inflammation, we are in a position to form a judgment as to the uses of pus, and the general significance of this most characteristic of all the manifestations of the inflammatory condition. Meanwhile, however, there are some physical qualities of pus, connected principally with abscess formation, which still remain to be noticed.

Significance of Odors from Pus.—The discharge from an abscess, especially in certain localities of the body, is liable to give off an offensive odor. This is due to contamination by fetid gases generated in the vicinity of the abscess—pus, like other substances containing fat, becoming readily tainted. Thus, the power by which gases permeate animal membranes, known as *osmosis*, explains the fetor of the pus from abscesses forming near the rectum, or, in fact, in the neighborhood of any part of the alimentary canal. The badly smelling gases generated within the intestines are absorbed by the pus formed outside of it, through the intervening membranes. This is true of pus forming in the neighborhood of the mouth, tonsils, pharynx, and œsophagus. A peculiar sour smell has been noticed in pus from the vicinity of the small intestine, suggestive of the earlier stages of digestion. There is, consequently, a certain diagnostic value in the odor of pus. If the discharge from an abscess of the neck should be offensive, it may be safely assumed to come from a source as deep as the pharynx.

In pus which is retained, and at the same time mingled with the secretions of an inflamed mucous membrane, as in that which occasionally collects in the antrum of the upper jaw, the fetor is excessive. In ozæna, or where dead bone is present, or a foreign body wedged in the nasal cavities, it is notoriously offensive. It is noticeable that in each of these cases the odor is peculiar, and differs from all others. Substances absorbed into the blood give their odor to pus: a French author states that ulcers of the leg in tanners, who work in badly smelling hides, are remarkable for their extreme fetor; and the odor of the dissecting rooms has been recognized in the pus of an

abscess following a dissecting wound. The pus from buboes of the plague is described as smelling horribly, and that from the pustules of smallpox is peculiarly disgusting.

Under other circumstances, when pus gives off a fetid odor, if this is not caused by the admixture of dead and sloughy material foreign to its own substance, it is the result of actual or approaching decomposition. In decomposition, the sulphates of its albumen become sulphurets, and free sulphuretted hydrogen is extricated, which combines with the ammonia given off at the same time. There is also a trace of phosphuretted hydrogen present which contributes to the odor. Decomposition of pus often takes place around a wound, where it collects and dries upon the surface in consequence of the high temperature of the body. When lotions containing lead are employed under these circumstances, the dressings are liable to be colored black by deposit of the sulphuret of lead.

POISONOUS QUALITIES OF PUS.—Opinions have varied strangely as to the possession of poisonous qualities by pus. Less than half a century ago, all the fatal surgical fevers were habitually ascribed to its reabsorption into the organism from wounds. After the old theory of pyæmia had ceased to prevail, pus was regarded, under the influence of the chemico-vital teachings of Robin, as a positively innocent substance. More recently a belief has become general that it possesses "infective" properties, the intimate nature of which is still under judgment. Thus we may say that normal pus, unless some virus or poison may have been accidentally introduced into it, has been usually regarded as a bland, innoxious, unirritating fluid. But experiments upon animals, first made as early as 1849, by Sédillot, and more lately by Billroth and Weber, Chauveau, Senator, and others, have demonstrated that not only pus, but other products of healthy inflammation, when introduced into the organism, possess the power of exciting inflammation in the form of abscess and fever. In the experiments of Senator, made for the purpose of studying fever, perfectly fresh healthy pus was injected beneath the integuments of healthy dogs, with the invariable effect of producing a rise of temperature within an hour or two; but a large proportion of the dogs thus treated died in a few days with symptoms of septicæmia. Chauveau has proved that the fever-producing quality of pus resides in its solid elements; for injections of filtered liquor puris were found to be innocuous.

These facts, and many others of similar import and equal interest, are to be kept under advisement; but inferences from them, as applicable to the human organism, are hardly as yet justifiable beyond the general admission that, in a certain degree, the products of healthy inflammation possess the *infective* quality.

Where a wound, or an ulcer, is partly gangrenous, or phagedænic, in fact, up to the time when a complete layer of healthy granulation has formed upon its surface, its pus will always contain more or less dead or dissolving tissue —*detritus*, as it is called. The yellowish-gray flocculent or leathery adherent material which cannot be washed away from the bottom of a wound or ulcer, in this condition, is simply dead tissue not yet cast off, because granulations are not as yet completely organized beneath it—the organization of a healthy layer of granulation tissue upon the living surface being absolutely requisite to insure the safe separation, in the normal order, of dead from living parts.

But there are certain circumstances under which pus does acquire poisonous properties which do not belong to it *per se*, as when it becomes, accidentally, the vehicle of a virus, as, for example, the virus of the contagious venereal ulcer called chancroid. Under these circumstances it is properly denominated "virulent pus." Here there is no difference whatever demonstrable by the

microscope, as yet, nor by the strictest chemical analysis, from pus of ordinary quality. The *virulence* of pus thus contaminated belongs neither to its corpuscles, nor to bacteria, but to certain unknown substances soluble in its serum, analogous to those which exist in the blood in syphilis, in the nasal mucus of glanders, or in the saliva of hydrophobia.[1]

Pus Involves Waste of Tissue.—It has been rendered sufficiently obvious by the preceding considerations that pus production involves destruction of tissue. As Stricker asserts, " where pus is formed in the midst of the tissues, the tissues must be disintegrated; it is the tissue itself which is transformed into pus-corpuscles." In addition, adjacent parts are damaged by interruption of their function, and by pressure; and local death is produced by ulceration. Pus production, in the case of wounds, therefore, involves not only delay as to healing, but positive destruction and waste of material in the consummation of the healing process; and suppuration is properly regarded as a symptom of the destructive phase of inflammation. These conclusions will become more obvious if we examine a little more closely into the uses of pus.

Uses of Pus.—For what purpose is this secretion furnished by the blood at the expense of the tissues? What are really its uses? These questions are readily answered. Many and different uses have been assigned to pus, some of which are entirely fanciful. James, of Exeter, who wrote in 1832, embodies the general sense, at that date, in the opinion that the secretion of pus is a necessary auxiliary to the process of granulation, for " the newly-formed parts have no protection to defend them against the injurious impressions of external agents;" this "appears to be its legitimate use." James judiciously remarks, concerning pus, that " if we can sufficiently protect the wound from the irritation of external agents it will heal without it;" referring to " scabbing," in proof.

At an earlier date, the flow of pus was supposed to exercise a *depurative* influence both upon the wound and upon the system at large. It was thought to cleanse a wound, and to prepare it for healing; and means were commonly employed to promote its flow. The popular mind still attaches importance to the idea that suppuration purges the body of something injurious; and the term "corruption" is still applied to pus, and a certain satisfaction excited by its free discharge. Hence one of the sources of confidence in the remedial power of setons and issues. But at the present day, the conviction has gradually come to prevail that these uses of pus are imaginary. They certainly have not been confirmed by the increasing accuracy of our knowledge, and the opinion of Robin is now generally received. This writer asserts, broadly, that " it cannot be demonstrated that under any circumstances suppuration does good, or that it exerts any salutary influence by depuration."[2]

We may safely regard suppuration as simply an exuberant overflow of plastic material. The leucocytes which are washed away from the surface of a wound are evidently not necessary for the success of the constructive process. They are in excess of the demand. Their fellows, which remain behind, develop into tissue—they subserve a useful purpose; but those which are washed away as pus-corpuscles are wasted—they are abortions. The truth of this view is confirmed by what happens when healthy granulating surfaces are brought in contact and kept carefully in apposition. We know by daily experience that they unite at once and grow together. The question was asked in connection with this mode of adhesion of granulations, or secondary

[1] Robin, op. cit., p. 414. [2] Op. cit., p. 384.

adhesion—"What, in this event, becomes of the pus?" The answer is obvious: It ceases to be produced the moment that the granulating surfaces are successfully brought together. The immediate demand for development into tissue, in the new attitude of the wound, affords ample scope for both the force and the material hitherto wasted; and the overflow, as pus, is at an end.

It is by this same mechanism that an abscess heals, after its contents have been discharged. The walls of the cavity, lined by granulations which have formed around the central cause of irritation by which the abscess was provoked, tend to come into contact as its contents are voided. The force that brings them together is the contractility of the tissues which form the walls of the cavity. If this tendency is intelligently favored, prompt adhesion follows, and the discharge of pus ceases. Just in proportion as this natural termination of the constructive inflammation is in any way prevented, the abscess is liable to result in a sinus. There is available evidence that suppuration is not only useless and wasteful, as shown by these examples, but that it is, in other ways, positively injurious.

And yet it may be remarked that, as far as the eliminative theory as to the causes of abscess formation is true, pus is to be credited as an adjuvant in floating out foreign substances lodged in the body, and noxious materials begotten within it. A flow of pus has also a certain usefulness in floating away foreign and dead matter from a foul surface, as, for example, from that of a contused wound, taking a helping part in what the older surgeons called "digestion" of the wound. To this extent, therefore, it may be regarded as as eliminating agent; and in the lower animals, after granulation has fairly begun, pus aids in forming a crust by which cicatrization is favored. Meanwhile it is to be observed that, when it cannot be cut short by promoting the adhesion of granulating surfaces—a possibility which the surgeon should always keep in view—the normal termination of suppuration is reached through the repressive influence of cicatrization.

Varieties of Pus.

The constitution of pus, as heretofore remarked, is subject to constant variety, not only in different individuals and forms of disease, but in different conditions of the same individual, and in different localities of the body. Under the influence of an attack of indigestion, for example, the character of the pus from a healthy granulating wound will give evidence of temporary change; and after a chill, as of pyæmia, it usually becomes scanty, thin, and watery. The sudden disappearance of the purulent discharge from a wound, simultaneously with the chill by which grave symptoms were ushered in, naturally suggested to the surgeons of the last generation that the serious change in the patient's condition was caused by "absorption of pus," and the abscesses in the internal organs which followed, seemed to lend support to this idea. But these facts are now explained differently.

In chronic and cold abscesses the pus-corpuscles have often a pallid, dropsical appearance, and sometimes their nuclei cannot be made apparent by adding acetic acid; these corpuscles have long since ceased to live, and are, in fact, beginning to undergo solution. The serum of this variety of pus is, consequently, rarely transparent; it is generally turbid. With these water-soaked pus-cells, others are found in a condition of fatty infiltration. In pus from abscess of the female breast, during lactation, milk-globules may be found, and in these, as well as in abscesses of the lymphatic glands, cells of pavement epithelium from the ducts, and also glandular cells, are often present. If we knew more of the subtle processes of organic chemistry carried

on in the tissues and fluids of our bodies, we should, doubtless, find many products derived from chemical changes in these unstable albuminous compounds, capable of acting as local irritants, and of causing these abscesses. Even thinner and paler than the pus of a cold abscess is that from cavities containing dead bone left behind after an abscess has failed to eliminate it; here we find sometimes drops of oil from dissolving marrow, as well as minute granules of osseous detritus which can sometimes be felt between the fingers. Careful scrutiny may, therefore, in any case, aid in diagnosis.

Pus from varicose and indolent ulcers, from ulcerated epithelial tumors, from the true syphilitic chancre, and also from phagedænic ulcers, is thin, serous, and "sanious," and contains more or less detritus of tissue—qualities significant of the absence of healthy effort in the way of repair. The type of *sanious* pus, of what is called *ichor*, is found in the discharge from an open cancer; it contains much already dead, or liquefying, cancer tissue. If, on the other hand, a cancerous tumor be removed, freely and entirely, and the wound left open, the surrounding healthy tissues will shortly eject cream-like pus, significant of active cell formation and rapid repair. Cancerous *ichor* is often excessive in quantity and exhausting to the strength of the patient; it is given off by the new vessels of the cancerous growth which are impotent to furnish true exudation, and simply exhaust vital force in the effort.

Substances Mistaken for Pus.

We have said that pus in a solid form has been mistaken for tubercle, when developed under pressure in bone. Solid pus occurs also, habitually, in other localities: in the sulci between the convolutions of the surface of the brain and spinal cord, in meningitis; on the iris, where it can often be seen in the form of little rounded masses, in iritis; in the cornea; and in other tissues of the eye. On the other hand, there are fluids in the body, and even solids, which are often miscalled pus, in which the microscope fails to reveal its characteristic elements. As examples, we have the fluid effused in peritonitis, or pleurisy, called purulent, but often nothing more than the serum of those cavities with a few leucocytes in suspension. An exaggerated flow of mucus from any of the mucous canals, with an increase in number of the leucocytes which it normally contains, often forms an imitation of pus—as in the fluid of bronchorrhœa, and of some forms of gleet, and especially in rectal mucus when colored yellow by bile. The fluid found in the pelves of the kidneys after death, resembles pus, but is only urine holding in suspension epithelium from the urinary tubules. A similar explanation applies to the fluid which can be pressed out of the prostatic ducts. The secretion of the tonsils collected in its crypts, is not unfrequently mistaken for pus, and ulceration assumed to be present, when it is not. Clots of blood which form in arteries after ligature, or after embolism, are liable to break down into a soft yellowish fluid strongly resembling pus;[1] and a similar puriform liquefaction is liable to take place in other tissues, as in lymphatic glands, sometimes in the testicle, and, more rarely, in the interior of fibrous tumors.

Injurious Consequences of Suppuration.

The vital effort which results in the formation of pus amongst the solid tissues of the body, just as in wounds and on membranous surfaces, only in a

[1] Virchow, Cellular Pathology. Translated by Chance. London, 1860.

greater degree, inevitably involves a destruction of existing tissue, besides the wasteful overflow of anatomical elements which we have already recognized. Wherever healing has followed suppuration, there is evidence, in the depression of the cicatrix, and in the general shrinkage in volume of the parts involved, that there has been loss as to bulk—certainly, also, as to quality—of pre-existing tissue. A cicatricial surface never contains sweat-glands, nor hair-bulbs, and only after a good deal of delay, according to Paget, the yellow elastic fibres. "But," it may be asked, "is not the healing of the wound to be credited to the suppuration?" By no means. A moment's reflection will recall the fact that the most prompt and solid healing with least loss of substance, is accomplished in primary union, in the subcutaneous consolidation of a divided tendon, and in that of a simple fracture, where there is no pus formation whatever; in short, that new tissue is freely generated without its aid.

Again, examples are occurring constantly, in practice, of patients wasting with suppuration who are benefited by cod-liver oil; and of amputation for injuries of limbs in which repair has failed, and where improvement in the patient's condition has begun at once after the removal of a source of exhausting and impotent suppuration. Daily experience tells us that hectic fever is coincident with, if not caused by, suppuration from surfaces incapable of healing. We have to add, also, to the injurious effects resulting from pus production, the possibility of amyloid degeneration of the arteries and the viscera; for modern pathology has recognized prolonged suppuration as one of the most common causes of this grave and obscure affection. The conclusion, therefore, seems to be unavoidable that the secretion of pus is not only, in a general way, useless and wasteful, but that it is, in many cases, positively injurious; while the benefit to be derived from it is uncertain, and in some degree, hypothetical.

It is desirable that the surgeon should recognize these truths, and assume it as a duty not only to favor rapid union in wounds, and a prompt cure in abscess and sinus, wherever this result is feasible, but under all circumstances to avoid suppuration as much as possible, and to arrest it always as soon as he can, keeping in mind the fact that the formation of pus involves the expenditure of vital force just as much as the construction of tissue.

Purulent Infiltration with Connective-Tissue Necrosis.

Three ways have been thus far described in which pus formation takes place in the organism: (1) on the surface of wounds healing by granulation; (2) on serous, mucous, and tegumentary surfaces; and (3) in the form of a collection imbedded in the tissues and bounded by well-defined walls, as an abscess. There is a fourth variety in which pus formation is not unfrequently encountered, namely, as an *infiltration* into the substance of a part—mostly into the meshes of the connective tissue, or into the cellular interspaces occupied by this substance—with a tendency to spread or travel, and showing no disposition to self-limitation as in abscess. From abscess, which is always characterized by limitary walls, this mode of pus formation is distinguished as *purulent infiltration*, and it is also often spoken of as "*diffused inflammation.*"

This obscure term was first applied by Duncan, of Edinburgh,[1] to the pus formation formerly so common in the axilla, and deeply amongst the muscles of the arm and thorax, after dissection wounds, and after venesection, in which

[1] Cases of Diffuse Inflammation of the Cellular Texture, with the Appearances on Dissection, and Observations. By Andrew Duncan, Jun., M.D., etc. Edinburgh Medico-Chirurgical Transactions, vol. i. p. 470, 1824.

the tendency to self-limitation was noticeably absent. It has since been applied by English surgeons to the diffuse and spreading suppuration attending erysipelas when this disease affects the parts beneath the surface. The French surgeons speak of this variety of inflammation as *diffused phlegmon.* The relation it bears to erysipelas has always been vaguely defined; but our ideas are clearer since modern surgical pathology has recognized that each of these forms of spreading inflammation, as well as simple cutaneous erysipelas, has for its cause a peculiar infective poison analogous to that discovered by Koch, by which he produced spreading gangrene in mice. The common effect of these poisons, in man, is to cause more or less rapid death of the connective tissue when brought in contact with its meshes by the lymphatics, or otherwise. The effect produced by putrid or altered urine, when extravasated into the connective tissue, illustrates the liability of this structure to die promptly in consequence of such noxious contact. It is the putrid element in this case that kills, for experience has demonstrated that the contact of healthy urine with the tissues does not necessarily impair their vitality.[1]

A contused wound of the hand in a mechanic, in which prompt healing has been prevented by neglect or exposure, is liable to become complicated by a diffuse swelling of the forearm, with purulent infiltration of its muscular interspaces. This complication has been described as "subfascial inflammation;" in reality it is a connective-tissue necrosis from poison brought by the lymphatics from the festering wound of the hand. Dr. Weir Mitchell, in his study of the effects of the venom of the rattlesnake, describes in detail the influence of this poison upon the tissues at and near the wound. When the victim survives the first effects upon the nerve centres, the suppuration that follows a snake-bite is of the diffuse variety—the half-poisoned tissues in the neighborhood seeming, for a time at least, unequal to the task of getting up a barrier of healthy granulations to limit its advance and serve as a basis for repair; and, before final healing, sloughy masses of dead tissue are always thrown off. This latter phenomenon is mentioned by Dr. Duncan in those of his cases of "diffused cellular inflammation" in which the patients survived; and it is a well-known feature in phlegmonous erysipelas, and "subfascial inflammation."

In a word, then, the pathology of the present day does not clearly recognize any especial significance in any of these terms, and tends to substitute for them *death of tissue from contact of a poison, and pus formation for the purpose of eliminating dead tissue.* The effort at pus formation is weak and diffuse, simply because the influence of the poisonous contact impairs in a greater or less degree the vitality of the neighboring tissues, and weakens their capacity for prompt and healthy repair. As soon as the poisonous influence ceases, more vigorous and healthy granulations are formed, and the production of new connective tissue goes on as in ordinary constructive inflammation.

The characteristic symptoms of this variety of inflammation are a peculiar doughy, boggy feel, attended by deep soreness on pressure, but rarely a distinct sense of fluctuation, with a variable amount of surface redness, perhaps a brawny thickening of the skin over the affected part, and a tendency to surface gangrene, in patches, from cutting off of the vascular supply of the skin. Thus, one of the best remedies of the surgeon is to save surface sloughing, and fever, by liberal incision of the integument, in order to facilitate the early escape of deeper sloughs. In these incisions he recog-

[1] In a patient shot through the distended bladder, recovery followed without any sloughing. (Van Buren. New York Medical Journal, May, 1865.) Subcutaneous injections of fresh healthy urine made experimentally by Keyes in man, were followed by no irritation or trouble whatever. (Van Buren and Keyes, Diseases of the Genito-urinary Organs, p. 144. New York, 1874.)

nizes a soft-solid condition of the subcutaneous layer, the meshes of which seem distended with fluid exudation of varying consistence, with softer portions of evidently dead tissue resembling wet tow and bathed in pus, and sometimes softened and dead muscular substance.

Hectic Fever.

As most frequently encountered in connection with the waste and consequent vital exhaustion from pus production attending lesions beyond repair, *Hectic Fever* is properly treated of as a symptom of destructive inflammation. It is a persistent, teasing, low form of continued fever, characterized by morning remission and nocturnal exacerbation; manifesting a pretty constant and regular succession of chill, fever, and sweating, in the course of every twenty-four hours; and characterized by progressive emaciation, with a tendency to a fatal termination unless its cause be removed.

The immediate or exciting *cause* of hectic, like that of the other surgical fevers, is, as far as we know, the absorption into the blood of some of the fever-producing products of inflammation, by small quantities—instalments, as it were—day by day, never sufficient to raise the temperature of the blood high enough to produce immediately fatal results, but keeping up a steady persistent drain upon the system in the way of combustion of the tissues. As to its remoter causes, hectic is neither an essential nor yet an eruptive fever; it is universally regarded as symptomatic, and, as already suggested, symptomatic of some lesion of the organism, generally attended by suppuration, with which the reparative powers are unable to cope. Chronic diseases of the larger joints, and compound fractures with ineffectual drainage, are common examples of the surgical lesions which cause hectic. It may exist where there is no actual suppuration, but such instances are rare.

The occurrence of hectic in phthisis is regarded as an indication that softening of tubercular deposit has taken place. A cold abscess may have been growing for many months without any evidence of fever; but if its contents be suddenly discharged, and the air has access to its cavity, a chill almost invariably occurs within a day or two, followed by fever and sweating; and the daily repetition of these phenomena marks the inauguration of hectic. If the vomica of the lungs, under exceptionally favorable circumstances, should heal, or if the walls of the abscess, instead of sloughing piecemeal, should unexpectedly granulate and adhere, the first evidence of this happy occurrence in either case would be cessation of the hectic fever. A case has been already mentioned in which the amputation of a thigh for chronic joint disease was followed by immediate and marked improvement; this was due to the cure of hectic by removal of its cause. One of the very common occasions of secondary amputation in hospital practice is irremediable injury of a limb, most frequently through the consequences of compound fracture, for the purpose of preventing death by hectic fever.

The fatal result is brought about surely and steadily by the waste of vital resources through combustion of tissue material to keep up the fever heat. Patients with hectic often consume a good deal of nourishment, but it seems to do them but little good; emaciation goes on in spite of the beef and the porter and the cod-liver oil. The eyes of the patient become more deeply set, the ears more transparent, and the outlines of the skeleton more distinctly visible. So in the dogs who were the subjects of Weber's fever experiments; the animals in a state of fever who were fed to the extent of their capacity, lost weight more rapidly than those without fever who were simply deprived of all food and dying of inanition. The slow progress of

hectic fever towards its usually fatal termination, is explained by the fact that the temperature of the blood is not sustained at a high figure; it rarely exceeds 103.5° Fahr., and falls two or three degrees in the morning under the influence of the nocturnal perspiration—sometimes even below the normal standard. Before midday, the chilly period, which may be very slight, comes on, and is followed inevitably during the remainder of the day by fever, and during the night by sweating, often profuse. Sometimes there is a double movement, with chilliness in the afternoon as well as in the morning.

The best diagnostic signs of hectic from typhoid or malarial fevers, are the regularity of the night-sweats in hectic, and the fact that the pulse retains its frequency during the apyrexia, even in the morning when the temperature is down to the natural degree. This depression of temperature in the morning bears a certain relation to the profuseness of the sweating during the night, and is associated with feelings of weakness and depression.

The worst signs in hectic are the intensification of its symptoms; increasing frequency of pulse; higher fever in the evening, with greater depression towards morning; more exhausting sweats at night, with the occurrence of diarrhœa, and aphthæ in the mouth. The sweats and diarrhœa are called *colliquative* in consequence of the rapid emaciation and exhaustion by which they are accompanied.

Chronic Inflammation.

Of all the various forms which the inflammatory process is liable to assume, the most common is that known as *chronic inflammation*, in which the condition tends to persist indefinitely, for the main reason that the object for which the increased nutritive effort has been undertaken has proved to be unattainable. The dominant idea, which will explain most of the phenomena peculiar to this condition, is the *non-fulfilment of a purpose.*

In chronic inflammation, all the cardinal symptoms may be present, but in a limited degree, the causes on which they depend being very much diminished in their intensity; *pain* is comparatively slight—it may be entirely absent, or intermittent, or possibly represented by itching; *heat* is generally recognizable, but is not a prominent symptom; *redness* is represented by a dull tint, sometimes livid, in consequence of passive hyperæmia from stretching of the vessels by previous over-distension and existing diminished activity of the circulation; *swelling*, the most important of the four, takes the form of induration, because the exudation has had time to become organized into tissue: hence the hard embankment around an indolent ulcer, and the almost cartilaginous hardness surrounding an old sinus—a fistula in ano, for example.

In the latter affection, which affords perhaps the best, because the most familiar, surgical illustration of chronic inflammation, an abscess has been prevented from healing by too much motion in its immediate neighborhood. Its walls have shrunken, but have failed to unite, through lack of sufficiently prolonged quiet contact; a limited amount of inflammatory exudation is still furnished, a portion of which goes to build up the sheathing of cartilaginous hardness outside of the cylindrical tube which remains, and the rest of which furnishes the scanty supply of serous pus yielded by the internal walls of the sinus. These walls are lined by what remains of the granulating surface of the original abscess. The granulations are now scanty in number and irregular in size; most of the surface is red and smooth, and, if closely examined, will be found, to the naked eye, to resemble mucous membrane. In fact, this close resemblance of the internal surface of an old sinus to a membrane, led to the impression, so long prevalent, that there was an especial membrane

whose office it was to secrete pus. The name *pyogenic*, or "pus-begetting," which was applied to this supposed membrane, is still in use in this sense; but the means of closer scrutiny now at our command have demonstrated clearly that no such membrane actually exists. The surface to which the name was applied is simply granulation tissue, in a passive condition of suspended development, awaiting its opportunity of final growth into tissue of cicatrix.

This is confirmed by what follows when such a sinus is laid open by the knife. Under these circumstances, the stimulus of injury starts the constructive effort anew; the chronic inflammation is replaced by a renewed afflux of blood; a fresh exudation of better quality is furnished; and the old surface of granulation tissue sprouts afresh in the effort at cicatrization.

The condition known as *induration* is one of the characteristic features of chronic inflammation. It is very familiar to us as a consequence of certain inflammations of internal organs, as in consolidation of the lungs, and cirrhosis of the liver; and it occurs constantly in surgical affections, notably around joints long diseased. Especially does induration take place where constructive inflammation has been prevented from attaining its object in the healing of a breach of continuity. The nutritive material, brought for the purpose of aiding repair, remains unused in the form of new tissue growth, more or less organized, which collects around the capillary vessels furnishing the exudation. It is new tissue formation intended for repair, but diverted from its object.

This increase in the numerical elements of the connective substance immediately surrounding the capillary vessels, constitutes, in the term first employed by Virchow, *hyperplasia*—a redundant tissue formation by elements which have been turned aside from their purpose. The use of this term serves to distinguish an increase in bulk caused by inflammatory induration, from *hypertrophy*, which is a purposive overgrowth of an organ generally provoked by its increased use; the habitually increased functional activity soliciting constantly a larger supply of nutritive material.

It is proper to notice that the new tissue growth which constitutes inflammatory induration, is less perfectly organized than the more normal growth of cicatricial tissue; hence induration may be removed by absorption, by atrophy, or by retrogressive changes, such as fatty degeneration. Thus, systematic pressure will cause the rapid disappearance of the embankment of induration surrounding a chronic ulcer of the leg.

It is well known that all new formations are less enduring in quality of organization than the original tissues of the body. Thus cicatrices are notoriously liable to injury by pressure, as in a leg stump after an amputation; and under the influence of exhausting diseases they may even re-ulcerate, as in scurvy. But the substance of inflammatory induration ranks still lower in the scale of textural vitality; and this lack of quality is constantly taken advantage of by the surgeon in treating the consequences of inflammation. In laying open old sinuses, the dense gristly character of the induration surrounding them may present itself as a discouraging feature as regards immediate cure; but, if the operation be thoroughly accomplished, the suspicious hardness of the "lardaceous tissue," as the French have called it, melts away with surprising promptness, and a soft bed of healthy granulation tissue succeeds.

In a *mucous membrane*, the induration, which is as characteristic of its chronic inflammations as suppuration is of their acute stage, is effected by exudative infiltration into the meshes of the submucous connective tissue. In *serous membranes*, similar thickening from induration occurs, but is less common.

Catarrhal Inflammations.

The group of inflammations called *catarrhal*, constitutes a variety presenting certain well-marked features. They occur in mucous membranes only, and, as the term catarrh implies, are characterized by increased discharge, as a cardinal symptom. Rarely acute, except when excited directly by traumatism, poisonous contact, or the influence of chilling, the catarrhal inflammations belong, therefore, to the chronic class, and, with the exceptions just noted, are chronic from the first, both as regards mildness of symptoms and tendency to indefinite continuance.

Some of the *causes* of chronic catarrh are exposure to habitual contact of irritating substances, as, in the case of the air-passages, to dust, to very cold or very warm air, or to sudden alterations of temperature; in the case of the urinary passages, to concentrated or exceptionally irritating urine; in the female passages, to acrid uterine discharges, aided by obstruction to circulation from the varying volume of the uterus. Certain constitutional and meteorological causes contribute strongly to the production of chronic catarrhal inflammation, *e. g.*, the peculiar irritability of membranes that belongs to the gouty diathesis; the relaxed condition and slowness to take on a healthy state after injury that occurs so constantly in the scrofulous; and sudden or frequent changes of temperature.

The *discharge* in catarrh consists of an increase in the normal secretion of the part by the addition of more or less inflammatory exudation. It contains also an increased number of cellular elements, besides the occasional mucous corpuscles and exfoliating epithelium usually present, in the shape of leucocytes and young epithelium. When the proportion of leucocytes is large, the discharge puts on the aspect of pus. Under these circumstances the grade of the inflammation more nearly approaches the acute form; exfoliation of epithelium is more complete; and the exudation from the sub-epithelial surfaces partakes more of the character of true inflammatory effusion. This exudation tends also to infiltrate the sub-epithelial connective layer surrounding the capillaries, with leucocytes, and thickening of the membrane follows as a consequence of their germination and development.

As to the changes which take place in the epithelium lining the follicles of an inflamed mucous membrane, histologists are not fully agreed. These little mucous glands often enlarge and become more prominent. As in follicular pharyngitis, their secretion fails to lubricate the gullet, and there are dryness and pain; or, as in urethritis, a little submucous abscess may form; or there may be ulceration from obstruction of the follicular outlet; but the latter is rare except in tuberculosis or epithelioma, or where there is coexisting disease of periosteum of bone, as in syphilitic ozæna.

The nature of the discharge in chronic catarrh is liable, therefore, to vary with the grade of the inflammation, the constitution of the individual, and the locality in which it is developed, as well as with the nature of its exciting cause. In regard to the latter, it is of the first importance to form a correct opinion. This is to be done by careful and thorough inspection of the affected surface, as far as possible, and by close scrutiny of the discharge as to its physical character, and especially its anatomical elements. It is not rare for a chronic discharge of the ear to be kept up by the presence of a foreign body; and this is also occasionally true of nasal catarrh. The odor of the discharge in the ozæna or scrofulous nasal catarrh of early life, is so peculiar as to be diagnostic; its vulgar name in France is taken from that of the bedbug. The odor exhaled by the nasal secretions of syphilis, even where no dead bone is present, is often very characteristic. As already

mentioned, the chemical decomposition of pus, in catarrh of the bladder, by the reaction of the ammonia of the retained urine, produces a gelatinous mass that usually passes for mucus, and its resemblance to the nasal mucus in an ordinary cold undoubtedly suggested this popular name for cystitis.

In conclusion, the general significance of chronic catarrhal inflammation is explained when we recognize that some constantly acting cause is producing an injurious effect upon an exposed mucous membrane; and the theory of its cure is mainly based upon the removal of this cause.

Inflammation in the Scrofulous.

The scrofulous catarrh of early life has just been mentioned as presenting peculiar characteristics. In truth, all the manifestations of inflammation in persons of the scrofulous diathesis present features so marked and characteristic, and differing in so many particulars from their ordinary aspect, that it is proper to study inflammation in the scrofulous as presenting one of the most important varieties of the process.

This constitutional diathesis has been always recognized, and its signs are so well known that it is useless to dwell on them. Nor is it necessary here to discuss the facts which seem to justify a belief in the infective properties of tubercle, and to differentiate it from scrofula as its sole source of origin. It certainly finds a more congenial soil in the scrofulous. The influence of the latter diathesis upon the series of vascular and textural changes following injury, principally concerns us, and, after stating categorically the several modes in which this influence is manifested, we shall endeavor to reach the safest basis for treatment of inflammation in the scrofulous.

It is in early life that the characteristics of scrofula are most apparent. They are seen in the tendency to enlargement of the lymphatic glands, and in the proclivity to certain forms of skin eruption, and to disease of the joints and bones. The effort required for growth and development at this period of life, seems to overtax the defective vital powers of those who inherit or acquire the diathesis. The lack of vital power manifests itself primarily in the quality of the blood, and consequently in the want of vigor and effectiveness in the nutritive machinery, and in the defective quality of the tissues and organs just indicated, but especially in the vascular tissue. There is apparently less want of power in growth, than in development; and this is shown mainly in this lack of textural quality. A scrofulous child grows finely for several years, and then, without any adequate cause, is overtaken by meningitis, or by disease of the vertebræ. The same peculiarity in textural development is manifest in the repair of injuries in the scrofulous. In the process of constructive inflammation, cell production and germination are prompt and profuse, but the subsequent development of the cells into healthy tissue for complete and perfect repair is liable to fail.

Thus a sprained ankle which, in a growing girl of healthy constitution, would get well certainly in two or three weeks, in a scrofulous child may fail entirely to recover, and may become the starting point of chronic disease of the joint. It is defect in vital quality and power in the vascular tissue that explains such results as this, which are not uncommon in the scrofulous. Capillary vessels are not formed rapidly enough in the organizing granulation tissue to furnish a sufficient supply of blood; hence its constituent cells cease to develop; they linger in an overgrown but unnatural attitude, constituting the material that gives its name and its fusiform shape to that form of white swelling known as gelatiniform degeneration. The want of an adequate blood-supply leads to other changes in the growing cells: they undergo fatty

degeneration, and become transformed into a yellowish material with the appearance and consistence of soft cheese. This material has heretofore been regarded as tubercle; but it is now rendered exceedingly probable that it is, in the majority of cases, nothing more than a result of degeneration of the constructive materials contributed for a reparative purpose in the normal course of the inflammatory effort, but not sufficiently supplied with blood to secure their development into tissue.

The real nature of the true tubercular deposit is not yet certainly determined; but there seems to be evidence that it is generated more readily and with greater frequency in the scrofulous, although by no means necessarily, or invariably; and that, when thus generated, it tends to produce more rapid and mischievous results. Histology teaches at present, mainly on the authority of Rindfleisch, that in the inflammatory process in the scrofulous, the exudation cells are unusually large; that the white blood corpuscles, after escaping through the walls of the capillaries, take on ampler proportions than in healthy subjects. It is asserted that, in consequence of their size, their absorption by the lymphatics is rendered more difficult, as they cannot enter these vessels; and that this circumstance explains the slow disappearance of inflammatory induration in the scrofulous. Whether this be true or not, it has become sufficiently apparent why constructive inflammation is more slow and imperfect in its results in the individuals of this diathesis; and, also, that their tissues possess less power to resist destruction and waste in the way of suppuration; and that inflammation in them has a greater tendency, under all circumstances, to take on the chronic character.

In consequence of the difficulty and delay that attend tissue formation, it is not easy to bring a suppurating surface to the point of cicatrization. The granulations are usually pale, flabby, and scanty; and they bear gently stimulating applications with advantage. Hence the benefit derived from the injection of alcohol in the dermic abscesses of children. Hence, also, as regards the whole organism, with its equivalent defective qualities, comes the benefit derived from the purer air of the country, the more concentrated forms of food such as cod-liver oil and malt, and the drugs which increase the quantity of the nutritious constituents of the blood, such as iron and the hypophosphites.

Inflammation in the Syphilitic.

The permanent change impressed upon the blood, and consequently upon the whole organism, by the presence in it of the peculiar virus or poison of syphilis, is justly regarded as equivalent to a diathesis. Although the process of repair of injuries is usually effected in a normal manner in the syphilitic, yet some uncertainty is always present as to the possible occurrence of irregular symptoms due to the presence of the poison in the system. A higher law, so to speak, seems to prevail in certain systemic diseases, which confers a paramount power upon the directly nutritive function as regards its constructive manifestations. A patient suffering from cancer, is more liable, in some phases of the disease, to fracture of bone. This accident has occurred from simply changing the position of a patient in bed; and yet union of the fracture has followed in the usual time.

Most of the manifestations of syphilis are inflammatory in their character. There is a tendency to local hyperæmia or congestion, and also to exudation, provoked by the irritating quality of the poison present in the blood, and, also, to cell germination, and, in a vague, purposeless way, to the formation of fibroid tissue. These manifestations have the peculiarity of occurring in

limited areas or spots, as in the papular or so-called tubercular eruptions of syphilis. Nodes, and the characteristic gummatous tumors which appear late in the disease, are results of the same tendency to new growth of a peculiar inflammatory character. In the latter, there is evidence of inability to sustain constructive action, as shown in a tendency to central softening and subsequent absorption, after which a depressed cicatrix is left; or, to suppuration and ulceration—the latter often extending in such a way as to show that the poisoned blood has produced in the tissues a defective vitality; a weakness, and an inability to resist progressive destruction.

The most interesting feature of the syphilitic inflammations is that in most instances they are promptly controlled by certain drugs—mercury and iodine —which possess a remarkable power as antidotes to the poison upon the presence of which in the organism the disease depends.

Terminations of Inflammation.

The object and end of the local disturbance of nutrition which we call inflammation, is the repair of injury, or the removal from the organism of locally injurious influences. In the accomplishment of this end, and, indeed, when it fails in its accomplishment, there are certain incidents liable to occur during the process, which surgical writers have added to the simple facts of its result in success or failure, and described, technically, as *terminations* of inflammation. Thus, besides simple subsidence and disappearance of symptoms (*resolution*), and absolute failure (*gangrene*), *pus formation* and *ulceration* have both been added to the category of "terminations;" and, by some, *induration* and *chronic inflammation* are also included.

According to our present view of the subject, there are but three ways in which the inflammatory process may be correctly said to terminate:—

(1) By *resolution*, in which all the inflammatory symptoms, which may have been provoked, gradually lose their intensity and disappear; the affected parts resuming, as far as possible, their normal condition. This termination takes place, as a rule, where the injury has not been severe in its character, and the progress of the inflammation proportionally mild, that is, confined to its constructive phase.

(2) By *formation of new tissue*. In the repair of injury, the production of a new growth of tissue is the main resource by which this object is attained by inflammation. In the simplest form of union, by primary adhesion, as well as in a breach of continuity attended by loss of substance, where a mass of granulations is organized into a cicatrix, formation of new tissue is the all-important feature, as well as the final result, of the inflammatory process. It is for this purpose that inflamed parts tend to revert, at once, to their embryonic state as the first stage of organization and development. The formation of new tissue, therefore, is properly recognized as a termination of inflammation.

(3) By *gangrene*, or *local death*. This termination conveys the idea that an inflammatory effort to repair an injury has failed in its purpose, and that the injured part has died. The local death results from the ineffectual working of the nutritive machinery in the constructive attempt: ineffectual, because the injury has involved the capillaries and the connective tissue surrounding them to such an extent as to impede their functions and to render the injury irreparable by the resources of the organism; or because obstacles have arisen at a later period which have thwarted the reparative effort, and left the injured parts to die.

There are points which may be profitably noticed in connection with each of these terminations of inflammation.

Resolution.—In *resolution*, the exudation which nas caused the swelling undergoes absorption by the agency of the lymphatics. Its more serous portions are absorbed directly and rapidly. The same is true of the leucocytes and wandering cells, which are said to find their way readily into the lymphatics, but the process may be somewhat slower. Rindfleisch's opinion has already been noticed, that the exudation cells in scrofulous inflammations are often exceptions to this method of absorption, in consequence of their larger size. Under some circumstances the exudative products, when partially developed, undergo liquefaction, or degeneration, and subsequent absorption. Although in the process of resolution inflamed parts are said to return to their normal condition, this is not absolutely true under all circumstances. The changes impressed upon the vessels and nerves by the excessive nutritive effort, leave traces of their effects in what is called "weakness" of the parts. The evidence of this weakness is recognizable in certain modifications of sensibility, *e. g.*, increased liability to pain; a deeper discoloration of the surface under circumstances which invite it, as in a warm bath, through passive congestion of the capillaries which have been overstretched; and proneness to take on inflammatory action without sufficient cause.

Tissue Production.—The occurrence of *tissue production* as a final purpose or termination of inflammation, which is recognized by all recent authorities, is a culminating proof of the original reparative intention of the process. Whether in union by primary adhesion, in the process of healing under a scab, in subcutaneous consolidation, in the secondary adhesion of granulations, or in the accomplishment of cicatrization after protracted suppuration, tissue production is, in all, the medium by which the final purpose of repairing injuries is achieved.

In primary union, the increased nutritive effort may be scarcely recognizable by the presence of any of the symptoms of inflammation, and its result may be a barely perceptible linear cicatrix, and yet this result has been brought about by tissue production. Newly developed capillary loops are passing across the chasm through a delicate layer of granulation tissue, just organized. All the earlier phenomena of the inflammatory process: increased rapidity of capillary circulation, dilatation—afflux, in short—and exudation, have this end in view. This becomes apparent if we study these phenomena in the variations they present in inflammation as seen in the several original tissues of the body, varieties due to the different ways in which their nutritive blood-supply is accomplished, mainly as regards the size and peculiar arrangement of capillary vessels. Thus, the process as it occurs in bone explains the reason of its exceeding slowness, and, at the same time, illustrates the unerring tendency to reversion to the embryonic condition in order to reach the result of tissue production. The Haversian canals of the bony tissue enlarge by absorption of their walls, in order that sufficient vascular distension may take place under the influence of the afflux, to secure exudation. Stimulated by the exudation, as soon as it has taken place, the adjacent cells begin to germinate, and thus absorption of bone goes on until it becomes replaced by embryonic or granulation tissue, in which, in due time, the earthy salts are deposited, and the formation of callus accomplished. In case of an obstacle to its accomplishment, the conversion of bone into embryonic tissue goes on in a purposeless way, a collection of pus takes place, or the process lapses into a chronic stage, constituting caries, or chronic osteitis. In a similar manner, but more rapidly, the peculiar substance of muscle, tendon, or even of nerve,

is reproduced by the process of constructive inflammation. Surgical experience furnishes evidence, in restoration of function, of the fact of reproduction; but of the mechanism by which it is brought about in the more complex tissues, the nerves for example, we are not yet fully informed.

The most common example of tissue production, for obvious reasons, takes the form of connective tissue; and this occurs primarily, replacing the more complex tissues, as in the case of bone, muscle, and nerve substance, until more perfect reproduction, requiring additional time, can be elaborated. When this latter result is not attainable, parts are permanently replaced by connective tissue, as in most instances in which muscular fibres have been cut across in a wound, and in fibrous anchylosis of a joint. Where obstacles exist by which reparative tissue production is hindered, the nutritive materials furnished for new growth are wasted, as pus; the main end or purpose of the constructive inflammation being held in abeyance, awaiting, as it would seem, a more favorable opportunity.

But *suppuration*, occurring under the circumstances just described, or, in fact, under any circumstances, is in no sense a termination of inflammation; it is simply an incident—in many cases an accident—of the process, as we have shown already. In the same sense *ulceration* is incidental to the suppurative process, and not correctly called a termination of inflammation. It is an incident analogous to the absorption of the walls of the vascular canals in bone, acting solely in furtherance of the general process.

When inflammation, having been acute, subsides into a subacute or chronic stage, it is obviously not proper to speak of it as having terminated in *chronic inflammation*. The inflammation, in fact, has not terminated; it has merely lapsed into another phase, in which, in most instances, it is awaiting the final achievement of a purpose which has been obstructed and delayed. In this view it is also obvious that the accumulation of nutritive material in the form of *induration* cannot be admitted as a termination of inflammation. The hyperplastic formation is simply nutritive material diverted from its original purpose.

Gangrene, as a termination of inflammation, depends essentially upon the amount and nature of the injury, and especially upon the degree in which the capillary and larger nutrient vessels are unfitted for carrying on the local circulation. When the vitality of the vessels is seriously impaired, stasis and thrombosis may occur, and the capillaries may be prevented from carrying on their functions as they do under circumstances of less grave injury; consequently, local death becomes imminent. If actual death takes place in a limited area by this mechanism, the presence of the dead tissue, offering an additional obstacle to the local circulation, and additional provocation to afflux for its elimination, tends to favor the extension of the area of dying and dead tissues, and in this way spreading gangrene is explained. Thus the afflux of blood to repair injury becomes, by its obstructive influence upon the damaged vessels, in reality an additional cause of textural death; and in this sense parts may be said to be killed by gangrene. This premature termination of the reparative effort in local death, as in gangrene from other causes than inflammation, is due, therefore, to an obviously material cause, namely, an inadequate blood-supply.

The local action of poisons upon the tissues, especially upon the capillaries, may impair their vitality in a remarkable degree. This is illustrated by the well-known experiment of Ryneck, who injected the bloodvessels of a frog with a solution of chromic acid, destroying their power of reacting under ordinary stimuli. The singularly rapid serous exudation that follows in

some cases the sting of a wasp or a hornet, or the bite of a venomous snake, is probably due to this cause.

The recognition of gangrene may be for the moment a matter of doubt; within a day or two after a serious fracture of the leg, the coincidence of a livid color of the surface, from the ecchymosis of contusion, with large vesications—a not unfrequent occurrence—is very suggestive of this condition. Similar bullæ containing bloody serum often form in erysipelas, and the black patches which they leave on drying have been mistaken for spots of commencing gangrene. But the sensibility elicited by the prick of a needle, and the absence of odor, will decide the question. It has been truly said that the earliest symptoms of gangrene are usually those of intense inflammation; the swelling is hard, the pain burning and tensive, and the color livid. The pain then subsides, vesications make their appearance, and the parts put on a marbled purplish-yellow tint which afterwards becomes brown or grayish. Finally they become cold and insensible, and exhale a putrid odor.

Treatment of Inflammation.

The treatment of inflammation, an account of which will close this article, is necessarily derived, as far as it is logically consistent with inductive reasoning, from facts and considerations concerning the nature and causes of the process, such as those which have been somewhat imperfectly passed in review. But much that is most valuable in the practical management of inflammation, is derived from clinical observation and experience, and not from reasoning; and it is, therefore, empirical. The mode of action of some of the remedial measures which have been found most effective in practice, cannot be satisfactorily explained, in consequence of our imperfect knowledge. In the practical treatment of inflammation, the surgeon is, therefore, compelled to adopt an attitude of intelligent empiricism. He follows the course which has seemed to be the best, without rejecting what he cannot explain, relying upon the steady growth of more accurate and precise knowledge to throw light upon the *modus operandi* of some of his best remedies.

In the preceding pages much space has been given to the causes of inflammation, in the belief that their study offers the best illustration of its nature; and it has been assumed that this course would lead at the same time to an intelligent comprehension of the rational principles of treatment. One fact has been rendered apparent by the study of inflammation from this point of view, namely, that it is the normal tendency of inflamed parts to return to a condition of health as soon as the causes which produced the inflammation have been removed. In all that belongs to this department of the subject, this important fact, which lies at the foundation of all treatment, is to be kept constantly in view.

It is at once obvious that a large share of our ability to control the manifestations of inflammation, comes from the knowledge by which we are enabled to foresee and avoid the action of causes, both predisposing and exciting, which clinical experience has shown to be capable of provoking the inflammatory condition. Thoughtful and intelligent *prevention* will, therefore, necessarily constitute an important share of the surgeon's duty in his relations to inflammation, and it should receive our especial attention. The immunity from suppuration and the other manifestations of destructive inflammation promised by thoroughly carrying out the antiseptic methods of treating wounds, which will be made the subject of a separate article, serves

to illustrate the great and growing value of one of the forms of the preventive treatment of inflammation.

Next in order, and second only to prevention in importance, is the *detection and removal of the causes* which have provoked inflammation and are keeping it up; and here is a source of the great interest which attaches to the study of these causes. As examples of the importance of this indication for treatment, we may refer to the prompt improvement that follows the removal of a splinter which is keeping up a festering sore, of a foreign body in contact with the conjunctiva, of a stone from the bladder, of a nail from its inflamed matrix (as in onychia), or of a sequestrum of bone which has been keeping up the discharge from a sinus. Mr. Simon, who has so ably discussed this subject, remarks with great justice that "it is amongst the highest problems of pathology to discover new groups of cases capable of being treated like the above by the simple removal of their respective causes. With the various dyscrasial inflammations, for instance, which are now treated exclusively from an empirical basis, and consequently often without success, how great an achievement it would be, if their immediate causes could be made as palpable as the mechanical causes just spoken of, and could, like them, be distinctly aimed at and destroyed!"

A third indication of paramount importance in the treatment of inflammation, is to *secure favorable conditions* for the inception and progress of constructive inflammation, or repair. From this form of the inflammatory condition, which is absolutely necessary for the healing of wounds and injuries, everything is to be hoped. Its management requires all possible means for its protection from interference, and for the promotion of its objective purpose—which is a termination by resolution, or cicatrization, coincident with healthy repair of the injury by which it has been provoked. Of these means the most important are: rest, as nearly perfect as possible, for the whole body, and especially for the injured part; quiescence for the mind, as far as it is attainable; freedom from sources of external irritation—including protection of an external wound from the air; the best position for the injured part that can be secured—to promote relief from pain and equable local circulation; an equable temperature and purity of air, with an adequate supply thereof. These and other means useful for the same end will be considered more at length hereafter.

The proper temperature for an injured part is between 68° and 72° Fahrenheit. Frequent changes above or below these limits are incompatible with equability. For a healthy granulating wound, even a higher local temperature is not undesirable. Embryonic development takes place normally, within the natural body, at blood heat. It may be inferred that cell germination and the development of granulation tissue, which are identical processes, would be favored by a similar temperature. In any event, sudden chilling of a granulating surface should be scrupulously avoided. It has been known to produce a fatal invasion of traumatic tetanus.[1] Addison tells us that in the artificial incubation of the chick, the process is interrupted if the temperature falls below the normal standard of the female bird, which is higher than the human standard, namely 106° Fahr., and the vitality of the chick is endangered.

This is not the place to enforce the necessity of an adequate supply of oxygen to secure the favorable progress of all processes involving unusual demands upon the powers of the organism, but the importance of this condition for successful treatment of surgical injuries is constantly liable to be undervalued.

[1] Agnew, ut supra.

An ample air supply is a condition indispensable for health, and it is therefore a duty incumbent upon those who have charge of the sick, to secure for them their still more urgent rights in this respect. The minimum supply for each patient in the ward of a hospital is two thousand cubic feet. The mortality in typhus fever has reached its lowest figure, even in the uncertain winter climate of this latitude, in patients treated under canvass, and in temporary wooden houses.

The fourth and final indication for the treatment of inflammation includes all the means at our command for the *mitigation and control of its manifestations* when excessive, or when threatening to become destructive; and for their arrest when actually destructive. These comprise remedies competent to antagonize excessive manifestations, to repress their intensity, and to restrain them, if possible, within the limits of the constructive process.

The means at our command for meeting the requirements of the third and fourth indications will be discussed under the following titles: *rest and immobility; position; cold; heat and moisture; compression; blood-letting; drainage; revulsion; drugs; diet and nursing.*

Prevention.—But foremost in order comes prevention. We are to understand by the preventive treatment of inflammation, the employment of measures which tend to favor the process of repair—that phase of the inflammatory process which we have called, after Samuels, constructive; and, also, the means at our command to avert any excess, or to remedy any defect, of vascular action, which, besides defeating the reparative object of the process, would produce waste and destruction of tissue—constituting the phase of inflammation we have called destructive. The former is to be promoted; the latter to be avoided, and, if possible, prevented. Happily, in the great majority of cases, both of these ends are to be attained by the same means. When we have secured complete primary adhesion in a recent wound, as a rule, all danger from inflammation is at an end.

Keeping always in view the fact that inflammation is nothing more than an exaggerated, sometimes a perverted, effort on the part of the local nutritive apparatus to meet some emergency in which the integrity of the organism is threatened, our first duty is to favor in every way the healthy performance of the all-important nutritive function. This is to be accomplished by providing pure air to breathe, plenty of sunlight, good food to eat, with proper attention to the conditions and surroundings by which the normal performance of all the functions is promoted. The constitutional peculiarities and acquired habits of life of an individual who has sustained a surgical injury should always be made the subject of careful inquiry; and the patient's habitual food and drink, and his hours of eating and of attending to the calls of nature, should be imitated as closely as circumstances will permit. He is to be regarded as a machine, and placed in all respects in the position, as to surroundings, in which the machinery will work to the best advantage. At the same time, the influence of the mind upon the healthy performance of the physical functions is to be kept in view; fear and anxiety are as far as possible to be dispelled; and hope and confidence are to be inspired. As Claude Bernard has shown, fear and apprehension of danger tend to depress the normal temperature of the body, which is kept up by the proper working of the nutritive machinery; whilst hope and happy anticipations have a healthy stimulating effect.

The next duty of the surgeon in preventing undue inflammation, is the avoidance, as far as circumstances will permit, of all possible causes of interference with the process of normal repair, and especially of the causes liable

to provoke unhealthy or excessive manifestations. The phenomena attending the reparative act, although forming a part of the process of inflammation, are to be recognized and favored; not prevented. It is their excessive or perverted action which we have to guard against by our art. This subject will be more fully discussed hereafter. For the present, to avoid repetition, we may refer to the study of predisposing and exciting causes contained in the preceding pages, with the remark that the injurious action of certain amongst them is noticeably preventable. For example, if a patient is found to be under the influence of malaria, or if he is confined to a malarial locality, it would be eminently proper to place him under the prophylactic influence of quinine; in other words, to make a few grains of quinine a part of his daily diet. If he be found to be syphilitic, according to the stage of the constitutional poisoning—whether active or passive—it would be a judicious course for the surgeon to avail himself of the tonic and blood-making properties of iodine, or of minute doses of the bichloride of mercury.

But of all the preventive measures within our reach for the purpose of avoiding unhealthy inflammation in the treatment of open wounds, the precautions and means which constitute the antiseptic method of treating wounds have of late years grown into proportions of greatest magnitude. Judging from results alone, without attempting a decision as to the theory on which it is based, placing himself on the legitimate ground of intelligent empiricism, and following the plan which promises most benefit to his patient, the surgeon of to-day is forced by the logic of facts to adopt the method of Lister. The cicatrization of open wounds without pus and without delay, as if they were subcutaneous, or healing under a scab—a result which can be commanded with as much certainty as attends any human enterprise, if the details of the antiseptic method are scrupulously observed—constitutes one of these facts. Another is the greatly diminished frequency, if not the entire absence, of the infective forms of inflammation and fever in surgical cases treated by the antiseptic method when it has been conscientiously carried out from the inception of the case. But it is to be remarked that in the doubting allegiance of many, and their consequently feeble adhesion to the new method, and the carelessness as to details that comes from want of full faith, from prejudgment of the question, greater attachment to old methods, or unwillingness to learn new and troublesome details, there are impediments which interfere with its adoption. This will be arrived at ultimately, it is not unlikely, as a consequence of the greater material success, in the aggregate, of those surgeons who practise the antiseptic method in all its details, and possibly by improvement in those details. Meanwhile, antiseptics are gradually taking the place of antiphlogistics; the latter cease to be thought of in proportion as the former grow in the confidence of the profession; and the opinion is, on the whole, steadily gaining ground that antiseptics constitute the best preventive measures against unhealthy inflammation.

Popular experience is not an unfair test of the value of local remedies in preventing inflammatory complications. When surgery was as yet unworthy to be called a science, the favorite applications to wounds were spirituous tinctures, balsamic substances, resins, and turpentines; and they undoubtedly owed their popularity as vulneraries to their antiseptic qualities. One of them, with a reputation of several centuries, the "*baume du commandeur*," praised by Ambrose Paré, known in England as "friar's balsam," in our country as "Turlington balsam," has a place in the U. S. Pharmacopœia as the *compound tincture of benzoin*. Many a fresh wound bound up with this vulnerary, which is still largely used in domestic practice, and afterwards left undisturbed through full confidence in its healing virtues, has got well without "inflammation getting into it." Basilicon ointment, *ceratum resinæ*,

has a popular reputation due to the same cause. Alcohol was a favorite dressing for wounds with Nélaton, and it has had enthusiastic advocates. It is claimed that it coagulates albuminoid substances and renders them imputrescible, and at the same time "closes the smaller bloodvessels and arrests their power of absorption." It enjoys a large popularity in the form of Cologne water and its substitutes, and of "Pond's Extract." Spirit of camphor was the favorite lotion of the late Valentine Mott; and the *eau sédative* of Raspail, consisting mainly of camphor and common salt dissolved in alcohol, is a universal panacea in France.

Greasy applications exclude the air, and, when impregnated with an antiseptic balsam, form the bases of most ointments and salves used as dressings for wounds. The Peruvian ointment of the New York Hospital is one drachm of balsam of Peru to one ounce of simple cerate. Vaseline, which is antiseptic and entirely unalterable as regards rancidity, is gradually replacing other greasy applications.

It is noticeable as a feature of antiseptic dressings of all kinds, that they are associated with infrequency of wound dressing, mainly, it is to be presumed, on account of lack of evidence as to the necessity for frequent interference. This circumstance alone, as conducing to quietude and equability of temperature, favors rapid and healthy healing; and, other things being equal, that form of dressing which requires least frequent renewal is always to be preferred as a preventive of ill behavior of wounds through unhealthy inflammation.

Addison quotes the case of a boy who fell into a caldron of boiling pitch. In removing his clothing, the sleeves adhered so closely that they were necessarily left on his arms. The boy ultimately recovered; but the attendant expressed surprise that his arms had cicatrized more rapidly and perfectly than the other parts of the body which had enjoyed the benefit of his daily dressing.

Apart from the question of antiseptics, there is abundant clinical evidence that the exclusion of air favors kindly healing and tends to avert suppuration in surface lesions of the body, such as abrasions, and especially burns. On a small scale, the popular use of court plaster is in point; and the prompt application of an impermeable dressing of gum, with the addition of a little molasses to give it toughness, so long in use at the New York Hospital as a dressing for burns and scalds, has proved of great value. A mixture of collodion and castor oil is said to be employed in the same way at King's College Hospital, in London.

Rest and Immobility.—The great advantages to an injured part of perfect rest and freedom from disturbance by movement of every kind, have already been enumerated in the remarks on motion as one of the mechanical exciting causes of inflammation. Their paramount importance in the treatment of inflammation, both preventive and curative, cannot be too strongly enforced, for the reason especially that it is being constantly undervalued, professionally as well as popularly. The directions often given to a patient, in a perfunctory way, to keep an injured part quiet, should in most cases be enforced by surgical appliances by which its motions are rendered impossible. A patient, however intelligent and docile, can rarely keep a part quiet unless its movements are physically restrained, or unless he is reminded to do so by the recurrence of pain on motion, and this always involves additional injury; in view of this fact, the surgeon should not only advise, but enforce his advice. The lesson taught us by the ill behavior of trifling lesions of parts subjected to constant mobility, as, for example, the festering of an abrasion upon a knuckle, is entirely applicable to lesions of a graver character.

Destructive inflammation is often provoked by inadvertent motion, as in the case of a laborer, or a mechanic, with a spreading inflammation of the forearm following a neglected hurt of the hand, which could have been certainly prevented by timely precaution securing quietude and immobility. The average patient cannot understand that moving a wounded part can do it harm, as long as the motion does not give pain at the moment. It is as difficult for an open wound to granulate or cicatrize when continually subjected to motion, as for a rosebud to bloom whilst being carried in a buttonhole. Similarly, a wrenched ligament after a sprain cannot promptly regain its integrity unless the part to which it belongs is rendered immovable; nor can an inflamed eye get well whilst the organ is in constant use. Thus we must recognize it as an ultimate fact established by clinical experience, that too much motion is as certain to retard and pervert the process of repair, as it is to provoke and excite the destructive phases of the inflammatory process.

The means at the command of the surgeon by which he can most readily enforce quietude and immobility of a part are, primarily, splints and bandages, or strips of adhesive plaster. Even where confinement to bed might be thought sufficient, as in some forms of fracture, retentive appliances are generally indispensable. In the most firmly impacted fracture of the neck of the femur, it would be the best course to render the parts immovable. The so-called immovable apparatus, consisting of bandages hardened by gypsum, starch, dextrine, or the silicates, are easy of application, and useful for many lesions besides fracture. Billroth states that he has had a greater degree of success in the treatment of sprains since he adopted the use of the plaster of Paris bandage; and the value of the plaster jacket in disease of the vertebral processes and bodies has been demonstrated by Sayre. Carved wooden splints, and guttered splints of tin or wire, prepared felt, gutta-percha, or sole-leather, which can be moulded to the injured part, are available for lesions in the neighborhood of joints, where motion is especially to be guarded against. For smaller wounds, which are always liable, when neglected, to become sources of serious complication, strips of adhesive plaster, collodion, and even court-plaster, are of value. In wounds of the face where quick union is especially desired, to prevent scars, the latter form of plaster, when free from coloring matter, is very useful; also between minute sutures in plastic operations on the face, collodion being applied over the ends of the strips, but not upon the wound itself.

For securing rest by the relief of pain and consequent restlessness, which is often a source of additional injury after dressing a recent wound; for every form of nervous excitability accompanying surgical lesions; and above all for *traumatic delirium*, which is an expression of the most intense form of nervous excitement—always excepting hysteria—*opium* in some form, as the typical anodyne, is invaluable. This drug is of such great importance as an adjuvant in the treatment of inflammation, through the possession of these qualities, that it has acquired a reputation as one of its indispensable remedies. This reputation is due, in the first place, to its power in controlling the symptom of pain, and in the next place, to its influence over muscular irritability and the prevention of twitching, spasm, and consequent injurious mobility at the seat of inflammation. By this latter quality its well-earned reputation in the treatment of peritonitis has been attained; it not only arrests, for the time, the peristaltic squirming of the intestines, but slows the action of the diaphragm, thus favoring the adhesive results of inflammation, and averting fatal suppuration. Opium is in this manner eminently useful as a preventive of the destructive manifestations of the inflammatory process. Hence after dressing a surgical case, and having placed the injured part in the

best position, the next step in treatment is to administer an anodyne, or to leave directions for its administration in case of pain or restlessness.

As is the case with every favorite remedy, the power conferred by an anodyne of relieving mental distress, in most cases, as well as physical pain, is liable to be abused. An opiate should not be administered unless a distinct indication exists, for its use. In most cases it interferes with the functions of the stomach and intestines, and in conjunction with confinement to the horizontal position, so often indispensable after a surgical injury, its employment begets a necessity for laxative medicine, and thus interferes with the important blood-making function, and increases the tendency to constitutional disturbance and fever. Moreover, the administration of an anodyne, especially if its effect has been pleasant, often creates a desire on the part of the patient for its repetition when, perhaps, a sufficient indication is wanting. Thus, however much he may be tempted to exercise his power, the surgeon should be on his guard against the possibility of abusing it; he has in trust what has been justly called one of the greatest gifts of God to man, and should be careful to bestow it wisely.

Position.—The *position* of a part which has been the seat of an injury or a surgical operation, especially when seated in a limb, should always be considered in reference to the avoidance of pain at the time, and of provocation to subsequent inflammation. In this regard there are several points to be noted: (1) a position should be selected which favors the venous or return circulation, so as to avoid the danger of passive hyperæmia; (2) muscular relaxation is to be secured—as far as possible—in order to guard against the involuntary spasmodic action liable to be provoked by muscular tension; (3) if there is a wound, the position should be managed so as to favor the ready escape of all possible discharges; and (4) the position should be, as far as possible, agreeable to the patient's feelings.

It is hardly necessary to add that undue manipulation or change of position is to be avoided, and where this is absolutely required, in a case of serious lesion involving much pain, as in a compound fracture, it is often the wiser plan to bring the patient carefully under the influence of an anæsthetic before handling the part. The muscular relaxation secured by the anæsthetic, prevents spasmodic contractions which do harm by disturbing the relations of the fragments, and by possibly causing bleeding. And, moreover, when an anæsthetic acts kindly and without causing undue excitement or subsequent vomiting, it is a matter of clinical observation that there is less disposition to excessive vascular reaction after it has been employed. As after the administration of opium, there seems to be less tendency to undue inflammatory excitement than where the same amount of violence has been inflicted upon a perfectly conscious and sensitive patient. Those who have had the experience of undressing and opening a recently closed wound in order to secure a bleeding artery, without the aid of chloroform or ether, can bear witness to the greater frequency of positive febrile reaction after such a double strain upon the power of endurance.

Cold.—As a cause of inflammation, exposure to intense cold may literally freeze exposed parts, such as the nose, ears, or toes; but if the temperature be very gradually elevated, and the suspended capillary circulation be restored, as by gentle friction with snow or ice-water, the parts may be brought back to a normal or to a very slightly weakened condition. But if the temperature of the frozen parts be suddenly raised, as by entering a hot room or approaching a stove, they are liable to become intensely congested, livid, and possibly gangrenous; or to remain in a condition of chronic inflammation, with a lia-

bility to itching, vesication, and ulceration, as in *chilblain*. Tissues which have been frozen offer an analogy to tissues which have been poisoned, in respect of their weakened vitality and their tendency to take on a low degree of inflammation readily and from slight causes. But this weakened condition may, under favorable circumstances, be recovered from entirely.

Cold, in its effects upon the system at large, is distinctly tonic and "bracing," when it is not too severe or too much prolonged. In the latter case it acts as a powerful sedative to all the functions of life, producing an intense desire to sleep, and finally death, in stupor, by the arrest of function of the cells which generate nerve force, as in fatal collapse from shock of injury. Locally applied, cold—judiciously regulated as to its degree and mode of application—is regarded as a valuable means of diminishing the force of the circulation, and thereby of antagonizing a tendency to excessive vascular excitement in the earlier phases of inflammatory action. It acts not only as a local sedative, but, also, as an astringent.

Cold is usually applied by covering the part with a cloth wrung out of iced water, or saturated with an evaporating lotion. The latter form of application was habitually employed before ice came into general use. As these applications tend to become soon dried by the heat of the body, if a part is to be kept steadily at a lower temperature, they must be renewed at short intervals. This demands attentive nursing, for frequent change of temperature in a part, certainly in the early stage of inflammation, is harmful. These modes of applying cold are well replaced by *systematic irrigation*. If a vessel of iced-water be suspended above the part to be irrigated, and some strands of lamp wick be placed with one end at the bottom of the vessel and the other hanging over its side, the cold water can be made to drop steadily and continuously upon the cloth that covers the part. But a sheet of impermeable material must be placed beneath the part, so as to convey away the overflow, or the bedclothes will become saturated, and the patient's body possibly chilled. Cold with moisture, inopportunely brought to bear upon the organism, is a fertile cause of harm in many ways. A greater degree of cold, as a local application, may be secured when desirable by means of a caoutchouc bag, or bladder, filled with crushed ice and moulded to the part.

Cold, applied locally, has always been regarded favorably and employed largely in the treatment of inflammation, and it certainly possesses power, and a certain degree of value; but in practice its use is limited, because, as is evident, it involves trouble and care, and it is also undoubtedly capable of doing harm, if not employed with good judgment. In the first place, it is not well suited for open wounds; for granulations, as we have seen, are aided in their germination, growth, and development, by a warm temperature. Where a wound has been closed with a view to primary adhesion, dry dressing suits better, in connection with the gentle and equable pressure by which this mode of union is promoted. Neither positive cold, nor the alternations of temperature incident to its employment as a dressing, are favorable to the process of adhesive inflammation. It is a mode of dressing very commonly employed, and often in a somewhat perfunctory way, but it may be questioned if the application of cold as a preventive of excessive vascular action to a wound just closed is the wisest course to pursue. Prevention is an excellent measure, but here it might possibly prove officious, as excessive action may not occur, and more really useful measures may be excluded by its use. Absolute quietude for the part—a stump after an amputation, for example—and an equable temperature, with gentle uniform pressure accompanied by antiseptic precautions, will more certainly second Nature's efforts to bring about prompt union without complication, which is the result desired.

Cold applications may, under some circumstances, prove positively injurious.

The use of an ice bag, by producing excessive vascular contraction, has caused gangrene of the edges of a wound. It is to be observed, also, that after a cold application has been removed from a part, more or less vascular reaction always follows, in the way of afflux and increase of heat. Although the fact has not often been noticed, it is hard to believe that parts frozen by ether-spray, or freezing mixtures, to produce anæsthesia, are not more or less impaired in their vitality.

On the other hand, the use of an ice-cap to the shaved head has a positive value in the cerebro-meningitis which so often complicates wounds of this region. Esmarch especially praises cold in injuries of joints as preventing and controlling intense vascular excitement. The use of crushed ice in a bladder, which can be moulded to the part, is a favorite remedy for inflamed hemorrhoids in the early stage. In the excessive temperature of the body in fever, the cold bath and the cold pack are remedies of undoubted power in diminishing the danger of fatal injury to vital organs from the overheated blood.

Heat and Moisture.—Dry heat is well known for its efficiency in calming pain; and heat, with moisture, in the form of a poultice, constitutes, perhaps, the local remedy sanctioned by most general use for the relief of the pain and tensive heat of a local inflammation. Its soothing and relaxing effect upon the inflamed part is the reverse of the astringent, although sedative, action of cold. The latter finds the indication for its use in the very earliest evidences of excess in vascular action that succeed an injury, and here it constringes the capillaries of the inflaming part, and promotes a disposition to return to a normal condition—in other words, to a termination by resolution. On the other hand, the influence of moist heat upon the tissues of an inflaming part is distinctly relaxing, and, therefore, tends rather to promote exudation, if not suppuration. This tendency of a poultice or warm fomentation to favor suppuration, is an article of popular belief, but there is no absolute certainty of its truth. Habitually, in practice, cold applications are abandoned as soon as resolution seems unattainable, and poultices are substituted, on the assumption that suppuration is the next best result to be hoped for. At this juncture *compression* may be possibly introduced, tentatively, as an alternative, if the influence of the poultice in causing suppuration is feared. After this, if the pain continue, the use of the poultice is justified.

Where pain is a prominent symptom, it is an excellent plan to sprinkle the surface of a poultice with laudanum, or to anoint the inflamed part, when the skin is unbroken, with the ointment of stramonium or any other narcotic. In acute and painful inflammations of the testicle, the tobacco poultice has long been in use at the New York Hospital; it is very effective in epididymitis. It is a common practice in France and Germany, sanctioned by the authority of Velpeau and Billroth, to cover an inflamed surface with mercurial ointment before applying a poultice. This is based on the widespread belief, founded upon its singular efficiency in syphilitic inflammations, that this drug has a certain power in mitigating the intensity of the inflammatory act, and in rendering exudations more readily absorbable. There is no positive evidence that mercury possesses this power except in syphilis.

The materials which have been found to possess the best qualities as poultices, are freshly ground flaxseed and slippery elm bark. The consistence of a poultice and its emollient and unirritating character render it capable of being moulded in contact with the irregularities of surface of open and granulating wounds. The addition of vaseline, or of boracic acid, or of a weak solution of carbolic acid, will prevent fermentation in the poultice, and counteract putrefaction in the wound. The liberal application of the balsam

of Peru, which is a good antiseptic, to the surface of a contused wound before applying a poultice, is a favorite practice.

Poultices have been criticized as uncleanly, particularly by Liston, who strongly advocated "water dressing" as a substitute. In its most common form, water dressing consists of a cloth saturated with water or any medicated solution, and then covered in by oiled silk or some impermeable tissue to prevent evaporation and drying. Water dressing is a very useful application for inflamed surfaces. When the latter are irregular, absorbent cotton may be applied more accurately in contact with them, and then saturated with fluid, medicated or otherwise, and covered in. A solution of boracic acid or biborate of sodium is an excellent medication. A bandage is more conveniently applied over a water dressing than over a poultice. The latter, however, has by no means lost its place in either professional or popular confidence.

It is to be remarked that poultices are often continued unwisely long after the indications for their use have ceased. Their prolonged employment begets an unhealthy relaxation of the tissues thus subjected to too much maceration, by which the cuticle of neighboring sound integument is liable to become water-soaked and detached. In open wounds thus injudiciously treated, granulations tend to become exuberant, pale, and flabby, and cicatrization may be indefinitely deferred. Under these circumstances a change to dry dressing with moderate compression is often followed by benefit.

A very useful and beneficial mode of applying heat and moisture is by means of the local warm bath. In renewing dressings of open wounds of the extremities, it is constantly indicated. A tin vessel of proper size and shape to receive the forearm when the elbow is flexed, in which it may be subjected to prolonged immersion without inconvenience or fatigue on the part of the patient, who occupies a sitting position, is of great value; for example, after incision and a first dressing by compression or poultice in spreading inflammation extending up the forearm from an injured hand, a local bath of an hour or two before the surgeon's visit will add greatly to the patient's comfort and very much facilitate the subsequent dressing. Granulations have been found to form rapidly and grow well in a part submerged in tepid water; and for restoring an unhealthy wound or ulcer to a healthy condition, there is no better resource than a prolonged bath rendered antiseptic by carbolic acid or some other substance possessing similar properties. A thorough application of eight per cent. solution of chloride of zinc, followed by a prolonged local warm bath, has proved very effective in the disinfection of foul and unhealthy parts. As to the use of the general warm bath, its advisability must be determined by the condition and circumstances of the patient.

COMPRESSION.—Compression, if applied evenly, continuously, and not too forcibly, is a very valuable agent in the treatment of many of the phases of the inflammatory condition. It is capable of acting beneficially in several different ways according to the stage of the process. In acute inflammation, we have undoubtedly the power, by the use of systematic compression, of restraining the tendency to over-distension of the enlarging capillaries, and of limiting the amount of exudation; and in its chronic form, a wider range for application of the remedy, in promoting absorption. But the use of this power may be attended by pain, and no inconsiderable degree of danger. Of this we have clinical evidence in the cases recorded in which the testicle has sloughed after the application of strips of adhesive plaster to control acute epididymitis; and we may assume that instances in which this misfortune has occurred have been left unrecorded. This mode of treatment of inflammations of the

testicle by strapping, was at one time largely in vogue, but it has fallen greatly into disuse. The bad consequences which so often follow tight bandaging belong, also, to the category of ill effects which injudicious compression may cause.

It is in the later phases of inflammation, that compression may be employed with the greatest advantage. To aid resolution by increased support to the walls of vessels which have been over-distended, and are now tending to recontract; to favor the absorption of liquid and solid materials which have accumulated in the peri-vascular connective tissue by exudation; and in this way to prevent, under many circumstances, the formation of pus by expediting a return of the parts to a normal condition, are the results which may be accomplished by judicious compression. To keep healthy granulating surfaces in contact so as to secure their adhesion; to support and gently press together the walls of abscesses after evacuation, in view of a similar result; and to restrain serous exudation in parts weakened by inflammation, are additional illustrations of its utility.

But it is in chronic inflammation, and in facilitating the absorption of its products in the way of induration and accumulated neoplastic formation, that the employment of compression is, perhaps, most useful. An example of the benefit to be derived from systematic compression is afforded by the treatment of an indolent ulcer by strapping—after the method known as Baynton's, at one time in great repute—by which the surrounding embankment of induration is effaced by absorption, and its obstructed circulation restored. Another is seen in the shrinking of glandular swellings which have resulted from chronic inflammation. The mechanism of the cure in these cases is explained, in part, by the restored action of the lymphatics effected by the removal of the pressure caused by the obstructive new formation. It may be remarked that the power of iodine applied locally over glandular swellings, in promoting absorption, although highly sanctioned, is probably exaggerated, and notably inferior to that exercised by skilfully applied pressure. The remarkable effect of this drug in dissipating the gummatous swellings of syphilis has acquired for it more reputation than it deserves, as regards swellings of a different nature.

Compression, as employed in the treatment of inflammation, may be effected by different methods, each of which has its advantages. The ordinary roller bandage of undressed cotton-cloth is very useful in skilful hands, and applicable, extemporaneously, under many circumstances. By availing himself of the elasticity of cotton-wool, and placing two or more layers of ordinary cotton-batting upon the part to be compressed, the surgeon may apply a bandage tightly over the cotton without fear of causing any irregular constriction; and he will also secure by this device the additional advantage of keeping the part at an uniform temperature. These are points of decided value, for an even soft elastic pressure, with warmth unvarying in degree, are most useful conditions in the treatment of inflammation.

This method of dressing, with cotton, constitutes the "*appareil ouaté*" of Alphonse Guérin, who has employed it largely at the Hôtel Dieu, at Paris, claiming for it, when applied over recently closed wounds, absolute antiseptic properties. It is well known that air is deprived of all dust, and, therefore, of possible aerial germs, by being filtered through cotton-wool. Tyndall has shown that the most readily putrescible fluid in a test-tube, the mouth of which is plugged by cotton-wool, will remain free from putrefactive change indefinitely. This quality in cotton gives it additional value as a material for surgical dressings. Apart from our present purpose, the dressing of cotton wadding is a most useful resource in the treatment of fractures, where it aids in securing pressure enough to effect immobility without danger; and in

military surgery, where it is invaluable as a protective against the pain and danger incurred in transportation of the wounded.

A bandage of flannel is more elastic, and less liable to produce irregular constriction of a limb when applied by unskilful hands, as by those of a patient. This is still more true of the bandage of caoutchouc, which has been employed so successfully by Dr. Martin, of Boston, especially in the cure of varicose ulcers of the legs. A poor man may be cured by the use of this bandage without confinement from his daily labor, applying it without difficulty every morning with his own hands. It is undoubtedly superior to the elastic stocking, which can rarely be made so as to fit evenly at all points. The absorption of tumors has even been effected by its use.

An ingenious and effective mode of making pressure upon a limited area, as upon an inguinal gland, or a chronic ulcer of the leg, is by compressed sponge. A fine, dry sponge which has been thoroughly flattened by being placed for a few hours between two unyielding surfaces under a weight, may be applied over a chronically enlarged inguinal gland, or an indurated sinus, and confined in its place by a spica bandage; if some tepid water be now allowed to trickle down so as to moisten the sponge, it will exert a perfectly safe and painless but effective pressure upon the part as it returns to its original size. A disk of compressed sponge applied in this manner over a chronic ulcer with elevated edges and depressed centre, will moisten itself by the discharge provoked by its contact with the face of the ulcer, and entirely remove the unhealthy features of the sore. In the absence of pain, this dressing may be left undisturbed for forty-eight hours, and even in this short time an apparently incurable chronic sore has been found converted into a healthy granulating surface, which the subsequent use of the caoutchouc bandage has rapidly conducted to cicatrization.

Pressure may be conveniently applied in the groin, in some cases, by means of a truss, or, if the patient can be confined to his back, by the pressure of a bag of shot.

Blood-letting.—Before the middle of the present century, blood-letting in some form was universally regarded as the remedy of paramount importance in combating inflammation. This condition was regarded as a disease with pain, heat, and increased vascular action as its prominent symptoms; and because these were almost certain to be favorably modified, at least for the time, by the abstraction of blood, this measure became the great antiphlogistic remedy. It is certainly a remedy of power, and as certainly its power was abused, and its use carried to excess and misapplied; hence the revulsion against blood-letting which commenced during the last generation. This was aided by the rapid progress of pathology, after it had been placed upon an anatomical basis by the anatomical school. It had become evident that many diseases, before regarded as inflammatory, were entirely dependent upon other causes than those which constituted the inflammatory condition, and that they were not amenable to blood-letting; that, on the contrary, they were injured by it. The revulsion against bleeding, like all fluctuations in human opinion, has been carried to excess, and protests have been made, as by Sir James Paget, against its abandonment to such an exclusive degree.

In our country, there are climatic influences which have an adverse bearing upon the use of depletion as a remedy. The greater dryness of the atmosphere, and the extremes of temperature which characterize our climate, exercise a stimulating influence upon the nervous system, and the nervous centres are liable to disproportionate wear and tear. The conditions and surroundings of modern life, and the habitual use of more stimulating food and drink, tend to promote nervous exhaustion. The liability to extreme cold in

winter has led to the general use of the hot air furnace, the highly heated air containing, almost inevitably, more or less of the subtle carbonic oxide gas which finds its way through the cast-iron fire-box of the furnace. This gas, according to Bernard, acts directly upon the red corpuscles of the blood, destroying them fatally by simple contact, and producing, when habitually respired, an anæmic aspect.[1] It is not impossible that more red globules are destroyed, in the aggregate, in this way, than by the frequent blood-lettings practised by our ancestors. Red blood corpuscles are reproduced in the organism with wonderful rapidity, and this explains the strange tolerance of so serious a measure as the abstraction of large quantities of blood; but these reproductions must involve an expenditure of life-force which it would be better to economize. The circumstances of the rapid growth of cities, and of the diminishing tendency to out-door life, through desire to avoid exposure to extreme heat or cold, are not without their influence in depriving our population of their supply of oxygen.

At the present time, in our country, general bleeding is rarely employed. The aggregate sense of the profession, influenced, possibly, by considerations similar to those just advanced, seems to be adverse to its use as a remedy. The surgeon stands ready to bleed *ad deliquium* to prevent impending suffocation from hemorrhage in a wound of the lung, resorting to the remedy as a hæmostatic; but he would not bleed, subsequently, to prevent or control inflammation of the lung, because experience in military surgery has taught him that this rarely transcends the constructive stage, and that the greater danger in wounds of this organ is threatened from suppuration of the pleura, which no amount of depletion would prevent. Bleeding from the arm, by promptly lowering the action of the heart, might be of service in acute traumatic cerebro-meningitis, in view of the great danger of intra-cranial pus formation, and the soft texture and great vascularity of the encephalon; but in surgical fevers with a high temperature from blood-poisoning, this measure has proved of no avail.

On the other hand, the local abstraction of blood by means of leeches, cups, and other devices, is of great service in moderating vascular action, and in warding off destructive inflammatory symptoms. This effect is noticeable in inflammation of the eye after the remedy has been applied on the temple. In chronic inflammation of the knee-joint, cupping relieves pain and spasmodic twitching of the muscles; but its action is only temporary. After a recent wound or injury of the knee-joint threatening disorganization, a generous application of leeches in conjunction with immobility, the leeches being repeated promptly and heroically as often as the pain returns, is competent to restrain the inflammation within the bounds of repair, and thus, possibly, to save the articulation. The power of local bleeding to relieve hyperæmia is well seen in the prompt cessation of the intolerable pain of epididymitis in the condition known as strangulation, by the application of leeches over the cord. Here the over-distended veins of the cord are obstructed by the unyielding edges of the external abdominal ring, with consequent stagnation of circulation, and pressure upon the nerves going to the testicle.

These examples will serve to show the advantages which may be gained from local depletion. Repetition of the remedy is likely to be required to

[1] Describing the blood of a person who has been poisoned by carbonic oxide, as by the fumes of burning charcoal, he says: "If examined, it will be found to have lost its power of absorbing oxygen. It is the red blood globule especially which is altered; its function as an oxygen carrier is abolished. Once exposed to the contact of the carbonic oxide, a chemical change instantaneously takes place in its substance, and in consequence of this change it is thenceforward indifferent to oxygen. It becomes at once an inert body, a simple mineral atom, a grain of sand. Chemically, the oxide of carbon has driven out the oxygen from its combination with the hæmoglobuline of the red globule, and takes its place, volume for volume." (Leçons sur la chaleur animale, p. 196.)

counteract a tendency to renewed afflux, and thus to secure all the benefit it is capable of conferring.

Leeches are not properly applied to the scrotum, nor to the front of the neck, nor to any part where pressure may not be readily applied in the event of protracted oozing of blood after they have dropped; nor is their application judicious, as a rule, in the inflammations of children, in view of their liability to subsequent hemorrhage, and of the fact that loss of blood is badly borne in early life.

Incisions.—Incision in the treatment of inflammation is often a remedy of the first importance. It is required to meet two distinct indications: (1) as a means of relieving tension, and, with it, pain; and (2) for the purpose of evacuating pus, or allowing the escape of dead tissues.

Tension of the tissues, however produced, directly tends to provoke inflammation, and also to increase its destructiveness—as where the opening of an acute abscess is delayed. The redness and heat of skin that often occur in swelled legs, in dropsy, form another example. Tension is, therefore, one of the causes of inflammation; and incision is the remedy required in most cases for its relief. It is not unfrequently indicated for this purpose, let it be noticed, even where pus is not suspected to exist; and it is employed simply as a preventive of suppuration, and especially of ulceration. Superficial incisions have been advocated to relieve the tension of the skin in simple cutaneous erysipelas; but in such a self-limiting disease they are rarely required to meet this indication, although sometimes necessary to give issue to pus which may form at points where the connective tissue is lax, as in the eyelids.

When the presence of pus is suspected, but not rendered certain by fluctuation, then deeper incision, with the double view of relieving tension and also of liberating pus, if present, is very often a judicious measure. When incision involves only the thickness of the skin, it is a very simple proceeding; but when pus is to be sought for deeply, it becomes an operation of some delicacy, and the knife is to be supplemented by the director and finger, in exploration, in order to avoid possible danger to arteries and nerves.

For the double purpose of relieving tension and evacuating pus, very long incisions have been advocated by high authority in phlegmonous erysipelas; but here, and under all similar circumstances where this remedy is indicated, a number of short incisions, according to the necessity of the case, are to be preferred. Long incisions are but little more effective, and they require a much longer time for healing; they are, also, less easily manageable where it is desirable to avoid loss of blood. This may be a point of importance in phlegmonous erysipelas, in which depletion is illy borne. But by adopting the plan of making short incisions completely through the skin in rapid succession, and having an assistant ready to crowd a fragment of sponge or a wad of absorbent cotton into each instantly, and to make temporary pressure, loss of blood can be rendered very trivial. Where the integument is thickened, brawny, and intensely congested, there may be a free gush of blood from the distended surface vessels for the moment, but it subsides at once as the parts contract. There is no one of the minor operations of surgery more immediately beneficial than this. In phlegmonous erysipelas, and in all the spreading and diffuse inflammations, incision is the remedy of paramount utility, because death of subcutaneous tissue occurs early—sometimes, indeed, as the initial lesion of the case—and, until an avenue of escape is provided for the sloughs, pus formation tends to advance progressively beneath the skin, where it is liable to be attended by indefinite destruction of tissue. When timely and sufficiently ample openings have been provided, the destructive process is in most instances arrested at once. Incisions save the

integument which would otherwise be destroyed by the spontaneous formation of gangrenous patches—a result which, without this remedy, is almost inevitable. In this way, indeed, both the necessity and the great value of early, free, and bold incision is demonstrated.

In acute abscess, also, incisions should be made both early and freely. In an abscess of any size, the incision should be always made large enough to admit the forefinger for exploration. There is nothing more unsurgical than an insufficient puncture for the evacuation of pus. An opening in a position which is not fully and entirely depending, unless such a position cannot be secured, is equally reprehensible. Both of these common errors interfere with the promptly curative effect of a good remedy; they invite a continuance of the inflammatory condition, and the formation of a sinus. A clean incision through the skin is easily and certainly repaired, and cannot cause untoward bleeding unless the patient be a victim of the hemorrhagic diathesis, which can be ascertained beforehand by inquiry as to previous experiences, and then a twisted suture may be required. The extreme probability that, in acute abscess, there is absolute necessity for the evacuation of something of the nature of a *quasi* foreign body by which the collection has been provoked, renders delay in opening unwise after fluctuation has become recognizable; under these circumstances, delay involves a further continuance of the process of destructive inflammation, and is rarely justifiable.

On the other hand, in chronic and cold abscess, incision may be very properly delayed, or substituted by aspiration, or by a valvular puncture with a trocar, which may be promptly closed.

Drainage.—In dressing an open wound of any size for primary union, it is the surgeon's duty to provide a readily available outlet for any fluids that may collect within it. Otherwise these would separate the opposed surfaces as they accumulate, and surely defeat the object of the dressing.

The materials liable to collect in a closed wound are: (1) excess of thin liquid exudation, containing more or less blood clot in solution, giving the fluid a certain resemblance to blood; (2) blood, which, in most cases, coagulates; (3) oil, when fatty tissue has been divided to any extent; (4) after an interval, and some fever, pus.

These obstacles to prompt union by the constructive process may all be obviated with a good deal of certainty by the judicious employment of drains as a part of the dressing of the wound. In their absence, symptoms of destructive inflammation will almost inevitably follow, *e. g.*, pain, throbbing, heat, tension, and swelling, with more or less extensive surface redness. With these, there is constitutional disturbance and fever, and, sooner or later, abscess. Drainage is, therefore, entitled to a place amongst the remedies in inflammation; and, if employed with tact and judgment, it will prove in most cases a most valuable resource both as a curative and as a preventive measure.

The proper mode of effecting the drainage of a wound is to place within it certain materials, such as caoutchouc tubing with lateral openings, strands of horsehair, of hempen thread, or silk—preferably waxed—or any other unirritating material capable of carrying off fluids by capillary conduction. These materials for draining should be thoroughly cleansed by immersion in a solution of carbolic acid or some other disinfecting preparation, before being placed in a wound; and they should be disposed, as regards size and number, according to its shape and extent, as detailed in other articles.

The selection of a proper position for a depending outlet in opening an abscess, or in securing a direct avenue for the escape of pus wherever it tends to accumulate—by incision or puncture, and the introduction of a drainage tube—and such alteration in the position of the part as may be required to insure

its efficient action in preventing re-accumulation of fluid in a granulating cavity, will furnish an example of drainage as a remedy for inflammation; for such a measure positively removes impediments to repair, and prevents the indefinite continuance of pus formation and other destructive symptoms. Experience teaches us by constant examples—in compound fracture as a very common one—how by a judicious change in position, say by suspending a limb, and by well placed incisions to receive drainage tubes, and thus to keep purulent cavities empty and to prevent pus from burrowing, pain and fever are relieved, redness and swelling disappear, and repair by healthy granulation and final cicatrization is secured.

Revulsion and Counter-Irritation.—*Revulsion*, or *derivation*, is effected by exciting an afflux of blood to another locality in more or less immediate proximity to an existing inflammatory focus, and thus drawing the blood away from the latter, so as to affect its condition favorably. This remedy for inflammation is also called *counter-irritation*, and it might with equal propriety be described as *substitution;* for it consists in artificially creating a controllable inflammation, with the object of cutting off the vascular supply—as by leeching, which is revulsive as well as depleting—from another inflammatory condition which is less controllable.

The means employed for producing revulsion are various: blisters, setons, issues, the moxa and other forms of the actual cautery, are all available, and more or less useful. They are mainly applicable to the chronic forms of inflammation, in which the more philosophical treatment by detection or removal of the cause which is keeping up the condition is not available.

As an exception to this latter statement, great virtue has been claimed for the application of a large blister over the chest, in averting traumatic pleurisy. Vesication has also been much advocated in chronic diseases of joints, and blisters are generally applied, of full size, alternately, on opposite sides of the articulation. Sometimes, however, smaller blisters are preferred, and they are rendered less transitory in their effects by being prevented from healing, and forced to suppurate, by a succession of irritating applications, thus converting the blister into a permanent issue. Blistering behind the ear by means of vesicating collodion is a favorite revulsive in eye inflammations. Blistering the perineum has proved serviceable in chronic gleet and in certain prostatic affections of early manhood.

The older surgeons attached great value to setons and issues in joint diseases. It is not many years since the insertion of a loop of caoutchouc behind the great trochanter, as a permanent seton, with cod-liver oil internally, and life in the open air, was considered the best treatment for hip-joint disease; and in comparison with confinement in bed in the horizontal position, previously in vogue, it was certainly a great improvement. The pea issue was a favorite remedy of Astley Cooper and Valentine Mott.

Firing, by means of the actual cautery, has been highly praised in chronic disease of the articulations. The modern facilities for using the actual cautery, and the employment of anæsthesia during its application, render it one of the most available, as it is one of the most effective, of the revulsives. The moxa, the favorite remedy of the elder Larrey, the fear of which no doubt prevented much malingering amongst the French soldiers, and the camphor moxa, one of its more recent substitutes, have given place to other forms of actual cautery. A dry surface eschar produced by nitric acid—the least painful in its application of the potential caustics—and left without any dressing, constitutes a mild but not inefficient form of counter-irritation. In the ordinary succession of remedies in chronic inflammation, the different forms of

revulsion and counter-irritation are usually preceded, if there is much local heat, by the application of leeches or cups.

Derivation by Ligation of Main Artery.—As long ago as 1813, it was proposed by Dr. Henry U. Onderdonk, of New York, as a remedy for inflammation, to cut off the supply of blood from an inflaming part by ligating its main arterial trunk.[1] Instances are on record in which this measure has been followed by good results. The femoral artery has been tied after a wound of the knee threatening destructive inflammation, with the effect, apparently, of saving the joint.[2] Though recently revived and ably advocated by Prof. H. F. Campbell, of Augusta, Georgia, and other surgeons, it is not probable that this somewhat hazardous remedy will be often employed. Partial arrest of the flow through a main artery by a compress placed under the dressing, has been employed with the object of preventing excessive reaction after an operation.

Diet and Nursing.—In inflammation, and particularly under circumstances in which it is liable to assume formidable proportions, the diet of the patient demands intelligent management on the part of the surgeon. On the one hand we have to deal with digestive organs enfeebled by the shock of injury, by pain, and by confinement to a bed with unsavory surroundings—and possibly weakened by disastrous depletion, or by exhausting discharges; on the other, we require the best blood which the patient's organs are competent to elaborate, and in adequate quantity, in order to carry on the work of repair, or replace the waste of fever.

The popular idea that low diet is necessary in the treatment of inflammation and fever, for the purpose of preventing and restraining excessive action, is based upon the same fallacy in which the word "antiphlogistic" took its origin—a term which, under the influence of the prevailing doctrines of pathology, has lost its significance and is falling into disuse. The facts are, simply, that the patient, in inflammation or fever, should be provided with the most nutritious articles of food that his stomach is able to digest, and in quantity, and at intervals, graded in accordance with its power to dispose of them. Adequate nutrition is to be sought for, and danger of repletion carefully guarded against. It is a judicious plan, in a serious case, to prescribe the hours at which food should be administered, as well as its quantity, in the form of written directions placed in full view of the attendants in charge, and to see that they are systematically enforced.

It is the popular belief that the medicines prescribed in a given case are more important to the patient than his food; whereas the reverse is generally true. Systematic and judicious feeding is, in truth, the basis on which successful treatment is founded. In the language of Bernard, the anatomical elements of our tissues, and the organs they compose, live in a medium—an atmosphere, so to speak—of blood, in which they are constantly bathed, and from which they derive all their sustenance. It is a paramount necessity, therefore, that the nutritive qualities of this all-important fluid should be constantly renewed by the mode which Nature has ordained.

There are many articles of diet usually regarded as appropriate food for the sick, the nutritious qualities of which are very much overrated. *Arrowroot* and *jelly*, for example, are almost worthless; and *beef-tea*, as usually prepared, is useful for little else than to supply blood salts. The use of these

[1] Letter to Dr. David Hosack, published in the American Medical and Philosophical Register, Aug. 1813.

[2] See a paper by Dr. David L. Rogers, in the New York Medical Journal, vol. iii. p. 453, 1824; and, also, "Surgical Essays," by the same author, 1849.

and similar articles of sick food is indicated where the appetite of the patient is greater than his power of digestion; they are momentarily satisfying, but innutritious.

Milk, as a rule, is the most valuable of all articles of diet in sickness. It is the best vehicle for stimulus in the form of spirit, when this is indicated, sheathing it like an emulsion and protecting the stomach from irritation. It is to be remembered that milk coagulates as soon as it is swallowed, and is equivalent to solid food. The addition of gelatine renders its clot less solid, and lime-water or mineral waters containing lime salts, like Seltzer water, make it more soft and digestible. A little solid food that can be chewed and properly insalivated is more acceptable to the stomach than a uniformly liquid diet. As to digestibility, *sweet-bread*, if not fried, ranks high, or *soft boiled egg* with bread crumb, and *beef*, even raw, grated, or reduced to a pulp and placed between thin slices of good stale buttered bread, are examples of nutritious and digestible solid food. The intervals at which food is given should rarely exceed two hours, with one longer interval, if possible, for rest.

As for *stimulus*, if it is administered with judgment, *alcohol* is eminently useful, both as a cardiac stimulus and as concentrated food. Its main quality is its fitness, in concentration and ready assimilation, to tide the organism over an emergency; but it is not usually beneficial when employed for a long period as a constant article of food, for it tends to exhaust the irritability of the heart, and is provocative of inflammation, as a chemical irritant, in the tissues of the stomach and liver. A pure spirit given in small quantity, with milk, is the best and most available form of stimulus for prompt effect; it acts most certainly and directly upon the heart. *Wine-whey* is agreeable and serviceable. Of *wines*, champagne is grateful in an emergency; for regular use those containing tannin, of which pure Bordeaux of an ordinary quality is the type, are the best blood-makers.

Nursing, at the present day, has taken a very prominent attitude as the executive or administrative element in the treatment of surgical cases of disease; it has been reduced to an art, of which the students are subjected to regular training, with the result of producing a positive diminution of mortality, in the aggregate, of surgical cases treated by their aid, as shown in hospital practice.

A trained woman is always preferable to a man as a nurse, wherever her physical capacity is equal to the duty, and no other consideration forbids. There should be but one nurse in charge of a patient at one time, and this nurse should be held responsible for all the minuter details of the patient's management, and should exercise paramount authority, under the surgeon's instructions. Any divided allegiance on the part of the nurse imperils the safety of the patient. A nurse should be competent to take the patient's temperature and pulse, and record them, as well as the hours at which food and medicines are administered. Nature's processes are conducted in accordance with a system; and if we assume the office of ministering to them in the way of aid, or of attempting to modify or control them, our efforts must be conducted not only intelligently, but systematically.

Medicines Employed in the Treatment of Inflammations.—In discussing the virtues of drugs, we are entirely in the domain of empiricism. They are to be judged of by evidence derived from observation, and this, as is proved by the conflicting opinions held by men otherwise equally reliable, is often faulty. As in regard to the value of blood-letting as a remedy, the general and apparently established sense of the profession may undergo a radical

change. Experiments upon animals have a more fixed and reliable value, but it is restricted within narrow limits.

Amongst the articles of the *Materia medica* which have been found useful in the treatment of inflammation, *opium* has the first place. Its great virtues in lessening pain and securing quietude of mind and body have been already under consideration. *Chloroform* and *sulphuric ether* are invaluable in surgery, and they exercise a certain controlling influence over the inflammatory condition, mainly as preventives, which is generally recognized, but very difficult to define. It is apparently due to their wonderful power of temporarily abolishing physical pain and mental consciousness, and, possibly, textural sensibility to harmful influences, and of preventing vital exhaustion—as we witness it in the shock of injury—by economizing the nerve force. Secondarily, anæsthetics tend to avert inflammation by facilitating the manipulations of the surgeon in operations, and in the dressing of wounds. Shortly after their first introduction, anæsthetics were unjustly blamed for some of the bad results of surgical injuries and operations; in the reaction of professional opinion, after nearly half a century of experience in their use, they are credited, more justly, amongst the great advantages which they have conferred upon mankind, with the power of diminishing, in a certain degree, the sensibility of the organism under injury, and the tendency to excessive inflammatory reaction.

Quinine is a most valuable medicine. After opium, there is none more constantly employed in the practice of surgery. As a tonic it occupies the first rank, promoting the failing appetite, aiding the digestion, and serving, like food, to directly increase the generation of nerve force. As an antidote to the poison which causes ague, and the fevers we call malarial, it is pre-eminent. If this poison is cryptogamic, as is more than probable, quinine is to be ranked high amongst the *antiseptics*. In the third place, quinine has the singular power of reducing the temperature of the blood in fever, and in the possession of this quality it is almost alone. It is not surprising that, possessing qualities which meet so many and such important indications, quinine should be so constantly prescribed in surgical practice. Naturally there is a disposition to carry the use of so valuable a remedy to excess, both in administering it in a vague and perfunctory way without any distinctly recognized indication for its use—simply because quinine usually does good—and also, by giving it in extravagant and excessive doses. Quinine in very large doses—twenty grains, and over—undoubtedly produces effects which cannot be otherwise secured, but it is required in this way only in exceptional cases, and for a short time; and these effects are generally due to its quality—through its sustaining influence upon the nervous centres—of preventing poisonous influences from raising the temperature of the blood. There is probably no poison against which quinine acts as an antidote in a curative way except the poison of ague. It was quite positively asserted not long since, by Helmholtz, to be an antidote to the poison which causes "hay fever;" but evidence as to any benefit from its use in this affection is wanting.

What shall be said of *mercury*, the drug which has been styled the Samson of the materia medica? Is it proper to speak of this most useful remedy as an antiphlogistic? Does it possess any curative influence over the inflammatory condition—excepting always its qualities as an efficient and manageable cathartic, and its revulsive action upon the intestinal canal—beyond its supreme power in favorably modifying the manifestations of syphilis? The weight of prevalent opinion tends to answer these questions negatively. The prestige enjoyed by this drug is mainly due to the remedial effects, which it produces with almost invariable certainty, in all the multiform symptoms which are caused by the presence in the blood of the syphilitic virus. As most

of these symptoms partake of the inflammatory character, the reputation of mercury as an antiphlogistic, because it removes them so readily, is explained. The visible melting away under the mercurial influence of the solid exudation often present in iritis, is constantly referred to as demonstrating the power of mercury to control inflammation. But iritis was not recognized as a consequence of syphilis until 1801, when it was pointed out by Beer; and, at present, its non-traumatic occurrence under any other influence than that of syphilis is regarded as exceedingly rare. We have no evidence that mercury will prevent, or cause the absorption of, the inflammatory exudation in pleurisy and peritonitis. In the latter, although no combination of drugs ever enjoyed more general confidence, opium, alone, has noticeably replaced the calomel and opium of the last generation. There is apparently valid evidence of the power of mercury to arrest acute bronchitis and acute cystitis, the symptoms yielding, as is asserted, as soon as the specific action of the mercury becomes manifest in the mouth; but in the cases which serve as a basis for this opinion, opium has also been administered in combination with the mercury.

As local applications, the lotions and ointments containing mercury are deservedly held in estimation as possessing salutary qualities beside their stimulating action. These qualities are habitually described by the rather vague term *alterative.* "Yellow wash," "black wash," mercurial ointment, and the cerates of "red" and "white precipitate" are universally employed for local medication, especially in unhealthy and chronic surface inflammations.

The preparations of *lead* are much prized in surgery for their sedative and astringent properties. The *emplastrum plumbi* as an unirritating retentive agent is simply invaluable. "Goulard's lotion," a dilute solution of the subacetate, is justly popular. The nitrate is more astringent, and also effective as a deodorizer; it has been used as a lotion in open cancerous ulcerations. The acetate, given internally in combination with opium, has a certain value as a sedative and hæmostatic. The soluble preparations of lead are all deodorizers in consequence of the readiness with which they decompose hydrosulphuric acid gas; and, for the same reason, dressings containing lead are liable to blackish discoloration from contact of this gas, which is always produced by decomposing pus.

The astringency and unirritating properties of the oxide and sulphate of *zinc* give them also great value as local applications in surface inflammations in the form of cerates and lotions. The oxide, mingled with pulverized starch, is used to dust over raw surfaces to promote their scabbing; the benzoated ointment of the oxide of zinc has replaced the old "calamine" salve in popularity; and solutions of the sulphate are widely used as lotions and injections in inflammatory conditions of mucous membranes.

The depleting and depressing effects of *saline laxatives* were formerly held in much esteem in inflammatory affections; but the fact that their action is secured at the expense of direct irritation of the blood-making intestinal surface, constitutes an objection to their use, save in the exceptional cases which by the suddenness of their invasion, or the violence of the inflammatory action, in a robust subject, justify this somewhat expensive mode of depletion and counter-irritation.

Apart from its depleting and disturbing influence upon the digestive surfaces, a mild but effectual *cathartic* is usually required in the beginning of a surgical case, and not unfrequently during its progress, to remove possible fecal accumulations in the large bowel. In surgical cases requiring rest in bed—as where bones are fractured—this measure is to be kept in view as necessary to favor healthy constructive inflammation. All possible disturbance of the patient is to be avoided by selecting an unirritating aperient, and by aiding its

action at the proper time by an enema of tepid water and a bed-pan of proper shape. In inflammation of joints, and in fracture, all risk of possible over-action of a cathartic is to be carefully guarded against, for positive harm to the inflamed or injured parts is likely to be caused by the disturbance.

There is no drug which exerts a more positive and undeniable power over a local development of inflammation than *colchicum* in a crisis of genuine podagra; but its good effects are limited to this disease. A knowledge of the *modus operandi* of colchicum in producing resolution of such intense manifestations of inflammation as those which characterize an attack of acute gout, would be of great interest if ascertainable. It seems to neutralize the poison in the blood, or to eliminate it by some emunctory, so as to save the white fibrous tissues from its noxious preference.

Aconite and *veratrum viride* have been extolled for their anti-inflammatory virtues, and many excellent practitioners believe in their salutary influence. But this faith is waning. Like *digitalis*, these drugs produce certain *quasi*-antiphlogistic phenomena, such as slowing the pulse and diminishing heat-production, but this effect is accomplished by their specific action upon the organism, as poisons; it is analogous to that which accompanies the shock of injury, and tends in no respect to remove the *causes* of the fever or inflammation, although certain of their symptoms may be temporarily controlled. These are remedies addressed to symptoms only; they are unphilosophical, and their value is more than doubtful. Stillé sums up the evidence against veratrum viride in terms which are conclusive, and ends with the solitary saving clause, that it may possibly do good in "cases of imminent or commencing congestion or inflammation, in which the maintenance of its sedative action upon the heart for a short period allows the conservative powers of the system to operate within normal limits."

For reasons similar to those which are now accumulating force against these depressing remedies, *tartar emetic* also has fallen into disuse. This drug was formerly held in estimation as second only to general bleeding in its power of controlling excessive vascular action; but through the same considerations which have brought blood-letting into disrepute, all these depressants are at present regarded by the profession with diminishing confidence.

As the science of surgery has advanced, the indications for the treatment of surgical diseases have become more precise; and it is desirable that these indications should always be sought for, and carefully studied. Otherwise the practitioner is in danger of becoming a routinist, instead of a scientific surgeon. Many remedies formerly in repute and sanctioned by the authority of great names, have lost their prestige, and are no longer in use; or are employed only in deference to custom and authority, and in a perfunctory way. Some of these remedies enjoyed great popular favor, a share of which extended to the surgeon who employed them; and this circumstance has tended to perpetuate their use. Even now a patient from the old countries will often crave a bleeding from the arm as a right, through traditional confidence in its virtue.

In the growth of more precise knowledge in pathology, the doctrine of blood-poisons, now dominant, is undoubtedly a principal cause of the changes which have taken place in the treatment of inflammation, especially as to the reluctance to employ depressing remedies. The general use of the microscope has revealed the infinitely delicate and elaborate structure of our tissues and organs, and has begotten a salutary indisposition to interfere with the vitality of their anatomical elements by means of agents which are harsh and violent in their action.

Antiseptics, as has been already remarked, are replacing *antiphlogistics*; and we find ourselves, therefore, obliged to consider the claims of the former as remedies for inflammation. Amongst the antiseptic substances which have recently attained prominence, *carbolic acid* holds, at present, the first place. This drug, practically introduced to the profession by Lister, owes its pre-eminence as an antiseptic to its volatile and pervading quality, in addition to its power of destroying the vitality of the lower forms of life without seriously endangering that of the human organism. There is no other of the antiseptic substances daily brought within our cognizance which possesses this combination of qualities in so eminent a degree. But chemistry may at any time present us with a substitute possessing superior qualities. Beyond this power of destroying the vitality of microscopic organisms which are noxious to our vital processes, and thus protecting us from their harmful action, there is no positive evidence that carbolic acid possesses any positively controlling quality as regards excessive vascular action, or any other of the manifestations of destructive inflammation. It simply secures for us free play for our reparative processes. This is the sum and substance of the antiseptic method of dressing wounds. Some of the other prominent antiseptics which have recently come into use, possess additional qualities. Thus *salicylic acid*, which is restricted in its antiseptic applications in consequences of its lack of volatility, has the power of lowering the temperature of the blood, and of controlling rheumatic inflammation.

The additions to our materia medica to be anticipated in the discovery of new antiseptics, especially of those with peculiar powers, promise, with what has been already gained for humanity in this direction, to add to our remedies in inflammation far more than we have lost by the exclusion of antiphlogistics. It will be a great gain to the science of surgery that the mode of action of these remedies can be explained on a basis of rational therapeutics.

ERYSIPELAS.

BY

ALFRED STILLÉ, M.D., LL.D.,

PROFESSOR OF THE THEORY AND PRACTICE OF MEDICINE AND OF CLINICAL MEDICINE IN THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA.

SYNONYMS.

English, *Erysipelas, the rose, St. Anthony's fire;* French, *Érysipèle, la rose, feu sacré, feu St. Antoine;* German, *Rose, Wundrose, Rothlauf;* Italian, *Risipola.*

ERYSIPELAS was originally a Greek word, but there is no general agreement respecting its etymology. That most generally adopted is that it is derived from ἐρύειν (to draw) and πέλας (near), "to draw near," because the name is supposed to indicate the spreading or wandering character of the eruption. Others derive it from ἐρυθρός (red) and πελός (livid), "livid redness," or from ἐρυθρός and πέλλα, "red skin." But an objection to the last etymology is that the Greek word πέλλα does not mean skin.

Erysipelas may be defined as an acute, specific, and contagious fever, tending usually towards a typhoid type, and characterized locally by a peculiar inflammation of the skin or mucous membranes. It may attack the same person more than once.

HISTORY OF ERYSIPELAS.

Erysipelas has been known from the earliest periods of medical history. Hippocrates gives a very particular account of it.[1] He relates that during a certain cold spring, many cases of erysipelas occurred with sore throat and loss of speech, adding that they were malignant and fatal. In many also, as from an accident, and sometimes even from a small wound, and especially in old persons, or if the wound were neglected, a great inflammation took place, and the erysipelas spread all over. In most instances, the inflammation ended in abscesses, and the flesh, tendons, and bones sloughed. It is particularly noticed that the discharge was not like pus, but a sort of putrefaction, or, as it would now be described, a sanious and ichorous discharge. When the scalp was attacked, we are told, the hair was apt to fall, and even the bones of the skull to exfoliate; and, it is added, bad as these symptoms were, they involved less danger than when the disease was determined inwardly. In some cases, it is said, the whole arm might drop off, and the bones of the thigh, leg, and foot be laid bare; but the most formidable cases were those which involved the pubes and the genital organs. This author briefly states the case of a man who had erysipelas of the foot and leg, with phlyctenæ,

[1] Epidemics, Book III.

and who became delirious and died on the second day; and he points out the exceptional gravity of the disease when it invades the head. Under the name of cancer, Celsus[1] describes a rodent ulcer around which the skin may grow red and painful, which condition, he adds, the Greeks called ἐρυσίπελας, adding that not only does it attack wounds, but it may also arise idiopathically, and that it becomes very dangerous when it affects the neck and head. From the time of Galen, accuracy of description was sacrificed to elaborate speculations concerning the nature of the disease, which, it was agreed, arose from a bilious humor that tended to escape from the skin where it occasioned the local phenomena of erysipelas.

Behind the veil of this myth is discernible the idea that the disease is not to be regarded as a local affection merely. In accordance with such belief, which was doubtless sustained by, if it did not originate in, the frequent occurrence of bilious vomiting at the commencement of an attack of erysipelas, emetics and cholagogue purgatives were enjoined as appropriate remedies, and they continue to be used, but upon more rational grounds, at the present day. On the other hand, a recognition of the frequent topical course as well as origin of erysipelas, is just as clearly indicated by the mode of treating it which prevailed among the later Greeks and the Romans, by means of astringent and refrigerant applications. Caution, however, was strongly enjoined by them lest a too active or too prolonged treatment of this description should induce gangrene; and Galen, as well as his successors, directed that when cooling (narcotic) herbs, vinegar, potter's clay, preparations of lead, verdigris, sulphur, alum, and other sedative astringents failed, and the parts grew livid, the skin should be incised and warm fomentations and poultices applied to it. The resulting ulcer, if one occurred, was to be dressed with honey or rose-oil rendered stimulant or astringent by the addition of wax, rosin, myrrh, etc. Nightshade, henbane, lettuce, horned poppy, opium, cicuta, and mandragora are also mentioned as proper dressings during the inflammatory stage of the disease. A poultice of bread-crumb with rose-oil, saffron, and opium, was applied in anal erysipelas. The Arabians omitted from their method of treating erysipelas the more repressive topical agents of the Galenical school, but retained the cataplasms and other lenitive applications; they administered gentle cholagogues and laxatives, and, while favoring venesection in sthenic cases, and especially in erysipelas of the head, warned against the tendency to exhaustion characteristic of the disease. In this, however, they only followed Paulus Ægineta, who, after describing "erysipelas of the brain," advised depletion from the ranine veins, and cooling applications to the scalp.

Causes of Erysipelas.

General Causes.—Whatever may be the specific cause of erysipelas, there is little doubt that certain external conditions favor its production, or at least its propagation. But care should be taken to distinguish between those which are essential, and those which are casual and contingent. It would be a waste of time to inquire into the greater or less susceptibility to the disease of persons of opposite *sexes* or different *ages*. Apart from the inherent vigor of certain persons as compared with others, there is no real difference to be noted. Indeed, as far as individuals are concerned, the chief distinction relating to their liability to erysipelas depends upon whether they present or not some lesion of the skin, and whether or not they have breathed an atmosphere charged with effluvia from a source capable of generating the disease. The

[1] Lib. v. cap. xxvi. sect. 31.

character of those sources will be pointed out presently. Meanwhile it may be stated that the exposure to such effluvia of any wound, great or small, incised, lacerated or punctured, recent or chronic, healthy or unhealthy, suppurating or not, may be sufficient to admit the virus of the disease. And equally is it true that any mucous membrane similarly exposed to receive that virus, may become the channel of its introduction into the system. These facts must always be taken into account while studying the general influences which seem to determine more or less the prevalence of the disease. Thus it is often said that the total number of cases of erysipelas, and their proportionate mortality, are greater during the winter and spring months, or from October to March inclusively, than during the summer and autumn, or from April to September inclusively. But to infer from this statement that *cold weather* was a cause, predisposing or exciting, of the disease, would be unwarrantable; since it is perfectly intelligible that, if the disease were propagated by a material poison, it would be more prevalent and fatal in close rooms during the winter, than in well-ventilated summer wards or apartments. In point of fact, however, the rule is not absolute, and it has happened that epidemics which began in the winter, have reached their height only during the following summer. One of the worst epidemics of erysipelas on record prevailed at Paris in the summer of 1861.

It is often remarked that erysipelas is apt to prevail or increase during cold and damp weather, and when the wind is easterly, and it has been charged that the habit of ventilating certain hospital wards in London, and elsewhere in the north of Europe, by opening the windows widely while the wind blew from the east, was frequently the means of producing and extending the disease. That being chilled sometimes develops erysipelas, seems certain; and some persons have attributed to cold a direct and independent power of producing it, on the strength of such cases as the following:—

A man subject to articular rheumatism was exposed to cold and wet, and after a chill was attacked with fever, and articular pains in a limb which presently became swollen, red, and covered with phlyctenæ; after a time the skin broke and discharged a large amount of sanious liquid, and then, as the patient was growing convalescent, he was attacked with erysipelas of the face, which ran its usual course.[1]

In this case, it is not certain that cold was the only morbid cause to which the patient was exposed. Of the case reported by Mr. Beale,[2] in which a child three weeks old was, without known cause, attacked with phlegmonous erysipelas of the left leg and thigh, which speedily proved fatal, it can only be said that the cause was unknown. Certainly, in many cases, erysipelas of the face follows exposure to cold, and especially to cold winds; but how far cold may be regarded as an essential cause, is uncertain. In like manner *cachectic conditions* seem to favor the development of the disease, but probably only by lessening resistance to the morbid poison on which the disease more directly depends. It would seem that Bright's disease in a special manner constitutes such a predisposition, as appears in the following instance related by Mr. Fergusson:—[3]

A woman of intemperate habits, who had albuminous urine, pricked her thumb; the wound soon grew painful and erysipelatous, and the inflammation in a phlegmonous form spread rapidly to the whole limb, terminating fatally about the ninth day.

The difficulty of accounting for attacks of erysipelas is aptly illustrated by the remark of Mr. Callender, made as lately as 1878,[4] that they sometimes

[1] Denoyer, Archives Générales de Médecine, Déc. 1878, p. 719.
[2] Lancet, March, 1860, p. 293. [3] Medical Times and Gazette, Aug. 1868, p. 211.
[4] St. Bartholomew's Hospital Reports, vol. xiv. p. 185.

seem "to grow out of the irritation caused by some acrid secretion by error allowed to remain in a wound." The term "acrid secretion" is familiar but indefinite, and is hardly to be accepted as correct in regard to any liquid at the moment of its secretion. But although any such liquid may become acrid by *putrefaction*, it is well known that no such change is necessary to produce even traumatic erysipelas, and to that alone the above remark applies. Nevertheless, the proofs of the origin of many cases of erysipelas in the emanations of decomposing organic matter are conclusive. Of this statement some illustrations may here be given. Dr. Begbie published several cases of erysipelas, one of which was traceable to the emanations of decomposing vegetable matter.[1] It is of interest in this instance to remark that the family attacked was from the country, and newly arrived in Edinburgh, while the other inmates of the infected house had long been resident there, and had doubtless become seasoned to its poisonous atmosphere.

Several years ago an English writer used this language: "There is now no more doubt that erysipelas is originated by sewer gas than that typhoid fever is more often than not due to impure water."[2] In numerous instances the prevalence of the disease has been proved to be coincident with the presence of choked drains, drains communicating with town sewers, or drains which had become permeable to fecal gases or liquids either by the corrosive action of their contents or by the gnawing of rats, while the subsidence of such local epidemics has coincided with a reformation of the existing defects in ventilation, sewerage, and water supply. As an example of these agencies, the case of the Somerset County (England) Lunatic Asylum may be cited. Between December and the following May, thirty-two cases of erysipelas occurred, of which four proved fatal, and, on investigation, it was found that none of the soil pipes were ventilated; one of them had a communication with the main sewer; most of them were of lead, and several of these were eaten and riddled with holes; and the main drain had, on one occasion, been blocked entirely to the extent of three or four yards. According to the same authority, in a large London hospital, pyæmia and erysipelas had prevailed to a deplorable extent, and, on examination, its means of ventilation were found to be very defective; but as soon as the defects were corrected and the pressure removed from the traps of the closets and lavatories, no fresh cases occurred. In another instance, an epidemic of the disease was distinctly traced to the stopping up of a ventilation-pipe by a careless workman.

The Sanitary Reports of England contain numerous instances which prove, like those just cited, that outbreaks of erysipelas, as well as of hospital gangrene and of fevers, are, with scarcely an exception, connected with serious defects of drainage or ventilation, or with a lack of any provision for isolating infection, or with some of these defects combined. Thus, at the Radcliffe Infirmary, where twenty-six persons affected with various diseases or injuries had been attacked with erysipelas, and five of them had died of the superinduced affection, the origin of the outbreak was undoubtedly owing to the imperfect arrangement of the drains, added to crowding, uncleanliness, and imperfect ventilation. At the Royal Infirmary, Manchester, recurring outbreaks of traumatic erysipelas had taken place, which were traced to the excessively foul drainage and to the overcrowding of the house with patients and attendants. The water-closets, baths, ward offices, and drains of the infirmary were placed within the building, and several of the closets were without direct communication with the outer air, so that sewer gas escaping from them necessarily passed into the corridors and wards. Under such con-

[1] Monthly Journal of Medical Science, Sept. 1852, p. 243.
[2] London Sanitary Record, June, 1879, pp. 357, 379.

ditions, wounds do not heal but are apt to be attacked with erysipelas or phagedæna; the natural processes of cicatrization, by which a firm barrier is established between the lesion and the system, are interfered with; the germs of disease and the products of putrefactive change are absorbed; and erysipelas and septicæmia ensue.

Besides the sources of infection now described, others may be mentioned, of which the following are examples. In Middlesex Hospital, London, it was observed that the only patients attacked with erysipelas in a certain ward were those who occupied two adjacent beds. After long searching in vain for the cause of this peculiarity, it was discovered that the pipe of a water-closet which ran behind the plaster of the wall at this place, was defective. It was repaired and no more cases of erysipelas occurred at the time. But ten years later, the same beds became again unhealthy with erysipelas, and the same remedy put an end to the disease. A perfectly similar case occurred in a Berlin hospital.[1] Again, in the hospital at Rostock, it was found that those patients only who had recently undergone surgical operations were attacked with erysipelas. After various fruitless researches the pillows of the operating tables which by long use had become saturated with blood, fell under suspicion, and were replaced by new ones, after which no more cases of the disease occurred. The soiled pillows were then treated with hot water, and an extract procured, with which two rabbits were inoculated. One escaped unharmed; but the other was attacked with severe inflammation of the skin and connective tissue, which spread extensively and was accompanied with blisters, gangrene, and fever, from which, however, the animal finally recovered.

Contagion.—The origin of erysipelas which has been described, and its relations to puerperal fever to be noticed further on, would of themselves render the contagiousness of the disease probable. But direct clinical proof is also abundant that erysipelas itself is communicable by contagion. The case is well known, which is reported by Campbell,[2] of a hospital ward in which the disease travelled from bed to bed in regular succession; but the following illustrations of the same import should be impressed upon the mind of every physician and surgeon.

During an epidemic of "putrid sore-throat," which prevailed in Dublin after an absence of more than twenty years, a lady was attacked with sore-throat and fever, and in the course of a few days erysipelas appeared upon her face. Her son, a robust youth of eighteen, who helped to nurse her, got "a whiff of sickening air from her bed-clothes," and immediately suffered from headache and fever. On the fourth day he complained of pain in the shoulder, followed by swelling under the pectoral muscles, which increased, and on the tenth day this region was covered with erysipelas which spread over the trunk. Bullæ formed, succeeded by gangrene; similar lesions affected the scrotum; and death took place on the fifteenth day.[3]

In 1852, a man arrived in Platte County, Missouri, suffering from erysipelas of the face. He was nursed by a farmer who himself fell ill just as his patient was beginning to improve. A second farmer who assisted in nursing both of the other persons, and slept in the same bed with them, was seized with the disease, and subsequently six other persons who helped to nurse the former patients were themselves attacked. Besides these, no other cases occurred in the neighborhood.[4]

Trousseau relates several instances of the contagiousness of the disease. In a certain house, the person first attacked died, as did the nurse who waited on him, while

[1] Berliner klin. Wochenschrift, 1868.
[2] Zuelzer, Ziemssen's Handbuch, Bd. ii. S. 416.
[3] Graves, Clinical Medicine, p. 576.
[4] New York Journal of Medicine, vol. x. p. 41.

several members of the family who came into contact with those first affected experienced serious illness. A lady contracted the disease from her son, a young physician who had caught it from erysipelatous patients in a hospital. A gentleman, whose frænum præputii had been divided, died from gangrenous erysipelas; shortly afterwards his wife, who had attended him assiduously, fell a victim to erysipelas of the throat and face, and the lady's maid suffered a similar attack, from which, however, she recovered. A gentleman received a gunshot wound of the foot followed by gangrenous and fatal erysipelas; his brother, who nursed him, was attacked with erysipelas of the scalp which ended in his death on the eighth day; his daughter, a child of three years, had a slight burn of the hand which became erysipelatous; the family laundress was affected with phlegmonous erysipelas of the right hand; the sick-nurse had erysipelas of the face and head; and a sister of charity, charged with the duty of irrigating the wounded foot, had a phlegmonous abscess of the right arm followed by several in other parts of the body, which sloughed, and finally caused the woman's death. Meanwhile, however, she had returned to her convent, where a number of the sisters were similarly affected, and two of them died. A hospital physician of Bordeaux admitted a patient with ophthalmia, placing him near one affected with phlyctenoid erysipelas; the former took the disease, and the physician, who had a slight excoriation of the lip, was also attacked. He was attended by his father, who was likewise a physician, and who contracted the disease and communicated it to his sister-in-law who came to visit him.

Dr. Mackay, a British naval surgeon, testifies strongly to the contagious nature of erysipelas as it was exemplified on board a man-of-war. The ship itself after thorough inspection was pronounced exceptionally pure, and the only source of the disease as an epidemic, seemed to be a case of "erythema," in a cachectic, syphilitic sailor; for, from his attack, and from contact with him, the subsequent cases appeared to take their rise. In several instances, the characteristic throat affection existed.

The case has elsewhere been quoted, but is appropriate here, of a physician who, having bled a person suffering under erysipelas following a burn, bled a man with the same lancet, the operation being followed by erysipelas and phlebitis, and also a woman who was attacked with puerperal fever.[1]

These cases all belong to a period of about a quarter of a century ago, and at that time the reality of the contagiousness of erysipelas was recognized by clinical observers; long, indeed, before it was admitted by scientific men, whose vision is sometimes more acute for abstract propositions than for the plain facts of experience. Thus the great surgeon, Velpeau, taught that erysipelas was not a simple inflammation of the skin, but the product of a special poison absorbed from without; and several other leading physicians and surgeons in France held the same opinion.

In a memoir addressed to the Academy of Medicine of Paris, in 1865, Blin cites the case of a young man who, after nursing in Paris a friend ill with erysipelas, returned to his village, where for a long time no case of the disease had occurred. Within a fortnight he died of it; then a servant who had nursed him was attacked, but recovered; a friend from a neighboring commune, which was free from the disease, came to visit the patient, after which he was attacked, and his wife also a little later. Four other persons who visited the last mentioned, took the disease, and the physician who attended them, his daughter, and the religious sister who nursed them, were all attacked, the physician fatally. In the report on Blin's memoir, Gosselin adverted to a number of analogous examples, and others were referred to in the discussion to which it gave rise. Nevertheless, the contagiousness of erysipelas was not frankly admitted,[2] and the reporter, Gosselin, in a later article on the disease, appears to be not thoroughly convinced of its contagiousness.[3]

In confirmation of the results of clinical observation which have now been brought forward to prove the contagiousness of erysipelas, it may be added

[1] American Medical Times, April, 1863, p. 198.
[2] Bulletin de l'Académie, t. xxx. p. 909.
[3] Nouveau Dictionnaire de Médecine, etc. t. xiv. p. 40.

that Mr. Goodhart has collected a number of cases from hospital practice,[1] which show that erysipelas may be communicated to persons suffering from diseases of the urinary passages, by means of an infected catheter, and that the affection thus induced may be attended with its usual constitutional symptoms, with an erysipelatous eruption on various parts of the skin, and with serious and often fatal inflammation of the bladder and kidneys.

Specific Cause of Erysipelas.—Of late there has been an evident leaning towards the adoption of the theory that erysipelas is produced by a specific virus. At all times, under one or another form, this doctrine has existed, and indeed it afforded the only rational explanation of the familiar fact that infectious and contagious diseases reproduce themselves under uniform types. Leuwenhoeck discovered bacteria nearly two hundred years ago, but it has required this long period to develop the existing doctrine which asserts that every one of such diseases depends directly upon a specific, organic form. The growth of this theory has been retarded by that of Zymosis, which, although purely fanciful in its conception, acquired such authority as to have its name applied in an official nomenclature to the group of idiopathic febrile diseases. But even if it were true, which it is not, that one and the same bacterium is uniformly found in connection with the same disease, the manner in which it occasions the specific phenomena of that disease, would thereby become no clearer. It has been suggested that each specific form of bacterium secretes a specific virus, which, in its turn, produces the specific, morbid type. But this is evidently an attempt to explain *ignotum per ignotius*. The present state of knowledge and opinion upon the subject, as far as relates to the disease we are engaged in studying, is perhaps expressed by Orth, whose elaborate experiments led him to the following conclusions:[2]—

1. Epidemic traumatie erysipelas is caused by a poison in the blood as well as in the secretions of the affected part.
2. These secretions are capable of producing erysipelas by inoculation.
3. Bacteria are generated pari passu with the development of erysipelas.
4. Bacteria stand intimately related to the septic cause of erysipelas, for its characteristic symptoms may be produced by artificially propagated bacteria.
5. But bacteria are only an indirect cause of the disease, since they are not formed abundantly in the blood of infected animals, and because they may be removed without entirely destroying the activity of the infecting liquid.
6. Bacteria appear to belong to the microspheres and the schizomycetes.
7. It is probable that in different forms of the disease different micro-organisms occur, but thus far no proof of this proposition exists.

In 1879, Tillmanns, of Leipzic, performed some experiments on this subject. Of twenty-five attempts to convey erysipelas by direct inoculation to healthy rabbits, a positive result was obtained in only five. In all the successful cases, the inoculated liquid contained bacteria, and the addition to it of a two to four per cent. carbolic acid solution rendered a previously active inoculating fluid quite inert. But the presence of bacteria, either in the secretions or in the tissues themselves, is not a constant feature in erysipelas. It is thus probable that not every case of erysipelas is brought about by the migration of bacteria as such, and that the advance of the disease is not in all cases connected with the presence of these micro-organisms.[3] According to Koch, the distinctive micro-organism of erysipelas is a bacillus.[4]

[1] Guy's Hospital Reports, 3d s., vol. xix. p. 357.
[2] Archiv f. experiment. Pathol. u. Pharm., Bd. i. S. 81.
[3] Edinburgh Medical Journal, vol. xxv. p. 666.
[4] Etiology of Traumatic Infective Diseases, New Sydenham Society's edition, 1880, p. 57.

Whether the hypothetical, specific contagium produces the symptoms of erysipelas by a direct and primary action upon the blood and nervous system; or whether it acts, first of all, upon the tissue that receives it, and only secondarily affects more distant organs; or, finally, whether it may and does, according to circumstances, act in both of these ways, is still an open question, and is very likely to remain unsolved. Very probably the erysipelatous poison may enter the system, either by a lesion of the integument or through the mucous membrane of the fauces and respiratory organs, precisely as the viruses of smallpox, measles, and scarlatina find admission. The rapidity with which it infects the blood and the type of the resulting fever, will depend upon several conditions, of which the most influential is probably the inherent activity of the poison itself, and the next is the power of resistance possessed by the patient. The latter again will depend in part upon the conditions that surround the patient, including fresh air, proper temperature and food, fatigue, cleanliness, etc.

The Causes of Erysipelas as illustrated by the History of Epidemic Outbreaks of the Disease.

The histories of epidemics of erysipelas remove any doubts of the septic and constitutional nature of the disease that may be suggested by a partial study of it in isolated medical and surgical cases. Even in the medical records of the latter part of the eighteenth century, it was pointed out that erysipelas began in the throat; and, although in some cases it appears to have been confounded with diphtheria, no doubt remains that an erysipelatous angina associated with erysipelas of the skin prevailed epidemically in Great Britain between 1777 and 1800, and subsequently in 1821, as well as occasionally even as late as 1832.[1] Daudé,[2] in his narrative of the epidemics of erysipelas that prevailed on the continent of Europe, refers to one that occurred in France in 1750, in which the symptoms were "difficult deglutition, hoarseness, swelling of the neck, and the other symptoms of quinsy," as well as to other epidemics of the disease in which pneumonia or diarrhœa existed as a complication. In almost every instance, the sore throat preceded the cutaneous inflammation, but some examples of the reverse order were met with. Daudé describes the disease as presenting the following categories: (1) Cases of erysipelas commencing in the skin and extending to internal parts, including the organs of deglutition and respiration, the vagina, and the rectum; (2) Cases beginning in the throat or the lungs, and thence spreading to the skin of the face, etc.; (3) Cases beginning in the throat or other internal part, and not involving the skin.

In the United States, epidemic erysipelas does not appear to have been observed until 1843 (a fact which of itself would demonstrate its specific origin), and it continued to prevail until the end of 1847. Another circumstance which also shows that it originated in some special, atmospheric cause, is that it prevailed within definite although extensive limits, which may roughly be indicated by the terms west and northwest of the Apalachian mountain range, and extending from Lake Champlain in the northeast, through the States of New York, Michigan, Indiana, Missouri, Mississippi and Louisiana, while it was almost unknown in southern New York, eastern Pennsylvania, and the other Atlantic States. Almost the only exception to this statement is the occurrence of an epidemic of the disease at Bridgeport, Conn., in 1847.[3] In

[1] Nunnely on Erysipelas. [2] Traité de l'érysipèle épidémique.
[3] Bennett, New York Journal of Medicine, July, 1853, p. 9.

the western and southwestern States, the name usually given to the affection was "Black tongue," which recalled one of its usual local symptoms, and suggested the distinctive type of the fever. On studying this epidemic in relation to the general subject of erysipelas, we find in the succession of its phenomena abundant evidence of its constitutional nature, and hence of that of other forms of erysipelas. For while, in some cases, the attack was ushered in by the simultaneous appearance of the throat affection and the general febrile phenomena, in many others the constitutional pyrexial disorder, even in an intense degree, preceded the anginose symptoms by one or more days, and even the glands of the neck swelled out of all proportion to the inflammation of the throat. The latter usually preceded the erysipelatous inflammation of the skin, which, according to some authorities, occurred in about one-sixth of the cases; but sometimes the opposite course was pursued, and, as has also been observed in Europe, the inflammation of the skin was primary and was seen to invade the throat by extension through the mouth or nostrils.

The condition of the throat was as various as that of the skin is in the several forms of cutaneous erysipelas. Sometimes the inflammation was superficial, the part of a bright red color, and neither the mucous membrane in general nor its glands were much swollen; but in other cases the fauces and the tongue were greatly swollen and purplish; and in others, again, dark or ash-colored sloughs formed upon the roof of the mouth and the soft palate. "The tongue was apt to be very much swollen, assuming a blackish-brown color, and deglutition was almost impossible," says Sutton, in his description of the Indiana epidemic of 1843. "In most cases an erysipelas would commence at the angle of the mouth or nose, and spread over the face and head. The inflammation of the throat sometimes passed down the trachea and bronchia, into the nostrils, frontal sinuses, or antrum maxillare, but usually the throat became well while the erysipelas was spreading over the skin." To these particulars it may be added that the sloughs above mentioned were apt to be preceded by bullæ or phlyctenæ filled with a serous and sometimes a bloody liquid. All who have described this affection note the great elongation and flaccidity of the uvula, and the sometimes enormous swelling of the lymphatic glands of the neck. In not a few cases, stated at one-twelfth of the whole, diffuse inflammation affected the connective tissue in the axilla, or below the pectoral muscles, sometimes extending underneath the great muscles of the back and over the entire trunk, or to two or more limbs, dissecting out the muscles, and often terminating in gangrene, with a discharge or the artificial removal of long shreds of dead connective tissue resembling wet tow, such as will presently be described as occurring in phlegmonous erysipelas of traumatic origin. In many of these cases, anginose symptoms with fever preceded for days, or even weeks, the diffused cellular inflammation referred to. According to the reporters of certain epidemics, the discharged liquid was so acrid "that the hardest steel was directly penetrated by it as by nitric acid."[1] In the most favorable cases, when a cure resulted, adhesions were apt to form between the denuded muscles and the skin, greatly and permanently restricting the movements of the part.

In the American as well as in the European epidemics, the internal complications formed a very important element of the disease, not only by increasing its gravity, but also by illustrating its nature as a blood disease. One of the first of its American historians, Sutton, describes as accompanying the erysipelas, a typhoid pneumonia, which sometimes was associated with swelling of the axillary glands; and he suggests that it might be regarded as a "pulmonic erysipelas." Ten years later this account was fully confirmed by Ben-

[1] Hall and Dexter, American Journal of the Medical Sciences, Jan. 1844.

nett, who particularly noted the predominance of the subcrepitant over the crepitant râle, and who also described the hurried and labored respiration of the attack. By this writer and by many others, the complication of the disease with inflammation of the serous membranes is much dwelt upon, especially with that of the pleura, peritoneum, and cerebral meninges. They also allude to the pain of a neuralgic character accompanying the first-named affection. In a fatal case, complicated with pleurisy, the softness of the exudation and the presence of bloody serum are noted. Peritonitis, both in the puerperal and the non-puerperal state, was recognized as the most formidable expression, or complication, of epidemic erysipelas. In the latter, the patient was seized with pain in the abdomen, vomiting, and diarrhœa, followed by great frequency of pulse and fatal collapse; and after death the peritoneum was seen to be dusky and injected, while its cavity contained a dark serum which presented occasional flakes of lymph, and exhaled a loathsome smell. The viscera were also darkly congested and softened. In the post-puerperal state the attack invariably commenced within forty-eight hours after delivery, with the same symptoms as in the non-puerperal cases, and, with rare exceptions, terminated fatally.

Having furnished this general sketch of epidemic erysipelas, it may prove instructive as well as interesting to present some examples of the association of the internal and external manifestations of the disease, which may serve to illustrate the essential unity of its various types. To show the growth of knowledge upon the subject, they will be presented in a nearly chronological order. As late as 1836, the nature of erysipelas was imperfectly recognized, and a teacher as acute as Latham endeavored to explain its various phases by representing the "disease" as at one time implicating the vascular, and at another time the nervous system. This ontological idea must, with our present light, be regarded as metaphorical, and as expressing nothing more than the fact common to all acute febrile diseases due to blood poisoning, that their phenomena may, according to the nature and dose of the morbid poison, be either sthenic or typhoid.[1]

In 1852, Blake[2] described the prevalence of erysipelas of the throat in California. was attended in some cases with fetid suppuration of the nostrils, in others with inflammation of the palpebral conjunctiva, or with a discharge of pus from the ears.

In 1855, Todd[3] referred to a form of erysipelas beginning in and confined to the pharynx, in which, on inspection, there was little swelling observed, but rather a dusky hue of the mucous membrane, and a remarkable loss of reflex excitability. Deglutition was very difficult, and food was very apt to pass into the larynx, excite strangling, and be rejected through the nostrils. In the same communication[4] he states that it was probably of this affection that Nicholas, Emperor of Russia, died, the disease having been erroneously styled "paralysis of the lungs."

In 1856, Gubler went so far as to maintain that erysipelas of the face was usually a propagation of the disease from the pharynx, although it might pursue the opposite course; and Trousseau, in a clinical lecture, took for his text a case in which the erysipelas was at first confined to the fauces and submaxillary glands, and only on the fourth day issued from the nostrils, and invaded the face and scalp, while it declined in the throat.[5]

In 1857, Forget[6] reported a case of erysipelas of the face in which the patient became convalescent on the eighth day; but directly afterwards a large abscess formed over each parotid gland, and one of them discharged through the auditory canal, while the accompanying symptoms were in a high degree typhoidal.

In 1858, Mr. Bird[7] drew particular attention to the frequency with which idiopathic

[1] Compare Latham's Works, vol. ii. p. 460.
[2] American Journal of the Medical Sciences, October. 1852, p. 60.
[3] Medical Times and Gazette, July, 1855, p. 28. [4] Ibid p. 27.
[5] Lectures on Clinical Medicine, New Sydenham Society's edition, vol. ii. p. 251.
[6] Bulletin de Thérapeutique, t. liii. p. 534. [7] Ranking's Abstract, 1859.

erysipelas made its first appearance, now on the face, and now in the throat, subsequently spreading from the one to the other part. He drew attention to the erysipelas of the throat which takes its origin in the wound of tracheotomy. Indeed, in not less than sixty per cent. of the cases of idiopathic erysipelas of the face observed by this surgeon, a diffused inflammation of the fauces occurred as a precursor; while in traumatic cases this local manifestation was rarely present. He very rationally suggested the reason of this difference in the following question: "Is it that the miasm in being inhaled into the lungs makes a direct impression on the throat, while in its entrance into the circulation by means of a wound this mode of contact is avoided?"

In 1859 and 1860, Dr. Todd again[1] noted the passage of erysipelas between the fauces and the face, in certain cases the nearly simultaneous affection of both localities, and the tendency of the disease to cause œdema of the larynx. He also related a case of surgical erysipelas of the thigh, which was in process of improvement when the patient was attacked with severe dyspnœa with bronchial râles, and died asphyxiated. On examination, the lungs were found greatly congested and œdematous, and the bronchia choked with mucus.

In 1861, Dechambre, describing the epidemic at Paris in the spring and summer of that year,[2] illustrated on a large scale the tendency of the disease to occupy the mucous membranes as well as the skin. Affecting the face, it caused an enormous swelling of the subcutaneous tissues, with phlyctenæ, abscesses, and tumefaction of the lymphatic glands. Often the neck grew so thick and hard that the veins were compressed, and the mucous membrane of the mouth and fauces acquired a dull, purple color; the tongue was dry and rough; deglutition was very difficult; and delirium, violent at first, grew more tranquil as it passed into coma vigil, or absolute stupor, often ceasing entirely twelve or twenty-four hours before death. In a certain case the inflammation began in the throat and extended through both Eustachian tubes, producing the characteristic pains of internal otitis; then appeared in the ears and spread upon the neck and face, advancing from both sides and meeting at the median line. In another case, the erysipelas started from the fauces, passed through the nostrils, and diffused itself upon the face.

In 1863, a writer[3] pointed out the distinctive marks of erysipelatous pharyngitis as follows: A crimson color, with œdematous swelling extending rapidly from the uvula and tonsils to the mouth, posterior fauces, and pharynx, causing so much swelling of the latter as to impede or prevent deglutition, and of the opening of the larynx as to hinder respiration and to alter the voice or occasion aphonia.

In 1865, Dr. John Ashhurst, Jr.,[4] published the case of a man who entered the hospital for a simple fracture of the metacarpal bones. A fortnight later he was about to quit the hospital, when he was attacked with acute febrile symptoms and considerable swelling of the fauces, which were mottled with yellowish shreds. On the following day erysipelas appeared upon the face, the parotid and submaxillary glands were enlarged and indurated, and the patient, falling into a typhoid state, died on the ninth day. On examination, it was found that the erysipelas extended through the larynx and trachea into the bronchia, and at the lower part of the trachea was a small ulcer. The heart contained large fibrinous clots, but elsewhere the blood was exceedingly black, and of about the consistence of molasses.

In the following instance, the progress of the disease was the reverse of that described in the last case. In 1864, Simon published[5] an account of a girl affected with erysipelas of the scalp, face, and neck; she then became unable to open her mouth, swallowed with difficulty, and grew aphonic. On the tenth day she died comatose. On examination, the mouth was pale, but the fauces were of a deep purple color, the follicles enlarged, and the mucous membrane softened. The same dark hue prevailed throughout the air passages which were dry and free from exudation. The lungs were greatly engorged, as were also the membranes of the brain.

In 1866 Dr. W. J. Wilson[6] described a case which began as sore throat, with pain-

[1] Clinical Lectures.
[2] Gazette Hebdomadaire, Juillet, 1861.
[3] American Medical Times, April, 1863, p. 196.
[4] American Journal of the Medical Sciences, July, 1865, p. 103.
[5] Bulletins et Mémoires de la Société Médicale des Hôpitaux de Paris, 2e série t. i. p. 199.
[6] American Journal of the Medical Sciences, July, 1866, p. 275.

ful deglutition, and swelling of one tonsil and of the neck externally. These symptoms, subsiding, were followed by laryngeal obstruction which required tracheotomy. The wound was attacked with erysipelas which spread over the skin, but the patient made a good recovery.

Not to prolong unduly this enumeration, a case of more recent occurrence may be noticed. Strauss[1] relates the history of a man who, during convalescence from an attack of erysipelas of the face and scalp, was seized with pain and swelling in the right side of the throat, while the corresponding lung was dull on percussion, and gave a crepitant râle in the lower lobe. But there was neither chill, cough, nor expectoration. In four days death occurred ; the pharynx and right bronchia were congested, but contained no fibrinous mould or filaments, and the alveoli were crowded with leucocytes.

With these examples before the reader, the bearing of the following remarks will be more apparent and intelligible. As long as erysipelas was regarded as merely an inflammation of the skin, the unity of the disease and its dependence upon a special poison were not readily recognized. Hence the artificial, although apparently practical, disjunction of medical and surgical erysipelas, which deluded learners, misled practitioners, and embarrassed authors. Continued observation, however, showed that the disease sometimes arose idiopathically, and was sometimes of traumatic origin, and that in both cases it could, on the one hand, be traced to certain definite causes, such as putrefaction, and yet might fail to occur when such causes existed in great activity, or might prevail fatally where no similar conditions could be detected. From such facts the rational conclusion could only be that beneath all the immediate and apparent causes of the disease, lay certain essential conditions of its production. But the time was not yet ripe for a demonstration of this proposition. Later, it began to be assumed that in all cases of erysipelas a positive lesion must exist to admit the poison, and, very frequently, minute inspection revealed, upon the skin, a pimple, a scratch, or a patch of herpes or eczema, which formed the starting-point of the erysipelatous inflammation, and sometimes an analogous lesion of the mouth or throat. However necessary it may be, and probably is, that a lesion of the skin should exist before erysipelatous infection can take place through that channel, for the sound skin is an exhaling and not an absorbing organ, the reverse is true of the mucous membranes, which are all, in various degrees, absorbing surfaces. If, therefore, erysipelas is disseminated by a materies morbi, it is only in accordance with a general law that it should frequently make its first impression upon the mouth, throat, and nostrils, as the poisons of smallpox, scarlet fever and measles, usually do; for if the poison is inhaled, it necessarily comes first in contact with these parts, and in its most concentrated form.

In traumatic or surgical erysipelas, the mode of entrance of the poison into the system hardly needs demonstration, for it is in wounds of all grades, from the most trifling abrasion to the most extensive removal of the integument by accident or by the surgeon's knife, that the starting-point of the disease is to be sought. Its characteristic phenomena are, indeed, not always first manifested at that point, for, as is more particularly set forth elsewhere, remote lymphatic ganglia are quite frequently the first parts to become swollen and painful; and in other cases, a febrile movement of a seemingly idiopathic nature sets in before the local phenomena, whether traumatic inflammation or glandular swelling, are developed. It is evident, then, that it is not erysipelas as an inflammation, which alone occasions redness over the lymphatic vessels and swelling of the corresponding glands, but that something is absorbed by those vessels from an infected wound or mucous mem-

[1] Medical News, Feb. 1880, p. 93.

brane, viz., the specific poison of the disease. Later, the morbid process takes on that peculiar form of inflammation which is known as erysipelatous; but it is important to bear in mind that the local phenomena, and especially the primary ones, are not necessarily proportioned to the general symptoms. A severe, and even a fatal erysipelas may follow infection through a trifling wound in the skin, or a short exposure to an erysipelatous atmosphere, just as a confluent variola may result from a like exposure to the contagion of smallpox. The specific virulence of the poison is, indeed, one element of its power, but the gravity of its effects also depends in no small degree upon the greater or less susceptibility and power of resistance of the patient.

Connection of Epidemic Erysipelas with Puerperal Fever.

The prevalence of erysipelas and puerperal fever at the same time, and in the same places, could hardly have failed to attract the attention of observant physicians at all times, yet the intimate relations between the two affections appear to be of comparatively recent discovery. Perhaps, even now, they are either quite unknown to many, or else their significance is misapprehended. It is very desirable, if these diseases stand related to each other as cause and effect, or, again, as common effects of the same cause, that it should be universally known both for the sake of removing the causes which are common to both of them, and for guiding the treatment demanded by the analogy, if not identity, of their nature.

The earliest opinion affirming a relationship between the two diseases, is ascribed to Pouteau, who in 1750 expressed his opinion that the puerperal fever which then prevailed in Paris was an erysipelas of the peritoneum.[1] From that time until the fourth decade of the present century, the subject does not appear to have attracted much attention; but in 1842, Mr. Storrs, of Leeds, England, reported that having attended a case of gangrenous erysipelas of the foot and leg, in which several abscesses formed, which he opened, he delivered several women in succession, all of whom were attacked with puerperal fever and died.[2] In the following year, Dr. O. W. Holmes related the history of a local epidemic of puerperal fever, which had its origin in the autopsy of a case which appears to have been one of gangrenous erysipelas of the leg. Several cases of erysipelas occurred in the house where this person died; the nurse who laid out the body of one of the puerperal patients died of sore throat and erysipelas of the skin; and another nurse met with a similar fate, without presenting, however, any sign of cutaneous erysipelas.[3] About the same time puerperal fever and erysipelas prevailed epidemically in Cincinnati, Ohio, and Dr. Minor of that city distinctly traced the propagation of each disease by the other, and from one patient to another by direct communication, including the production of erysipelas in the infants of mothers who had been attacked by puerperal fever.[4] In Missouri, the same coincidence and transmission of the diseases were frequently remarked, by Dr. G. W. Sickles among others.[5]

In 1850, a narrative was furnished by Hill[6] which illustrates the subject further:—

[1] Ranking's Half-yearly Abstract, 1859, p. 84.
[2] Provincial Medical and Surgical Journal, April, 1842.
[3] New England Quarterly Journal of Medicine and Surgery, April, 1843.
[4] Erysipelas and Childbed Fever, 1847.
[5] St. Louis Medical and Surgical Journal, vol. viii. p. 1.
[6] Monthly Journal of Medical Science, March, 1850, p. 299.

A carpenter wounded his hand while making a coffin, and, on placing the corpse in it, some fluid from the body came in contact with the wound. He had a severe attack of erysipelas, which he communicated to his wife. Meanwhile, their daughter, seven months pregnant, who had come home to be confined, was seized with fever. The physician, after visiting this woman, went to attend another in labor. The following day the carpenter's daughter gave birth to a dead child, and died of puerperal fever. The physician did not return to the other lying-in patient, who, however, suffered an attack of puerperal fever, but recovered. In the practice of the same physician, a girl suffering from erysipelas of the face was attended by her mother then about to be confined. The child was born with erysipelas and died. The midwife immediately afterwards attended a healthy girl in labor, who also had a mild attack of puerperal fever, but her father, who waited on her assiduously, was affected with erysipelas of the throat of which he died on the ninth day. Four other persons who assisted in nursing some of these patients were attacked with erysipelas, but recovered.

During a local outbreak of erysipelas in Platte County, Missouri, Dr. Ridley reports[1] that while attending cases of this disease, he acted as accoucheur to three ladies within the space of one week, all of whom were attacked with puerperal fever and died. These were the only cases in the locality. In 1852, an epidemic of malignant erysipelas occurred in New Castle, Pa. While attending one of the cases, Dr. Leasure delivered a healthy woman of her seventh child after a natural labor. She died on the fourth day of typhoid metro-peritonitis, and, after a like interval, her infant died of erysipelas. A second case occurred under identical circumstances, with like results for both mother and child, and the nurse also suffered from erysipelas, and barely escaped with her life. A third puerperal case of the same physician presented a similar history, as did two other cases under the care of another practitioner who had also been treating erysipelas. Both physicians then abstained from attending any more lying-in women, and no further cases of puerperal fever occurred. Dr. Leasure concludes his narrative with these words: "My cases of childbed fever were neither more nor less than cases of malignant erysipelas, fatally modified by the condition of the patients, and the manner of introducing the morbid poison.[2] About the same time, Dr. Todd, in England, said of puerperal peritonitis, it is "a disease which I believe is really of an erysipelatous nature."[3] Dr. Dutcher related several cases illustrative of this subject, of which the following is very significant:—[4]

A physician while attending a case of phlegmonous erysipelas was called to a case of confinement. The patient died of puerperal fever. In the course of four weeks he attended seven cases of labor, and in every instance the mother died of puerperal fever, while the children perished with general cutaneous erysipelas. Finally, the physician was himself attacked with erysipelas of the hand, which nearly proved fatal.

In Philadelphia the case is well remembered of a physician in extensive practice who had ninety-five cases of puerperal fever in rapid succession, while none were occurring in the practice of the neighboring practitioners; and of the children born in these cases no less than fifteen died of erysipelas. In 1857, Dr. Duncan, of York, Pa., related the case of a lady in whom an attack of puerperal fever occurred simultaneously with erysipelas of the face, while her infant suffered from erysipelas of the umbilicus.[5]

In 1862, a memoir upon this subject was published in Paris by Pihan-Dufeillay,[6] who clearly demonstrated the relations of the two diseases to

[1] New York Journal of Medicine, vol. x. p. 41, 1853.
[2] American Journal of the Medical Sciences, January, 1856, p. 45.
[3] Medical Times and Gazette, July, 1855, p. 28.
[4] American Journal of the Medical Sciences, January, 1856, p. 99.
[5] North American Medico-Chirurgical Review, vol. i. p. 31.
[6] L'Union Médicale, and American Medical Times, vol. v. p. 60.

one another by numerous examples, domestic and foreign. He maintained that there were cases in which the same cause seemed to engender both diseases, which differed from one another only in their subordinate characters, but were identical in their nature; as appears when, under the same general conditions, erysipelas ravages surgical wards, and puerperal fever lying-in hospitals or wards. If the conjunction were rare, it might be viewed as a simple coincidence, but its frequent repetition, if not uniform occurrence, and that not in one country alone, but in Europe and America alike, leaves no rational doubt that an intimate relationship exists between the two diseases. Of the two, the primary affection is sometimes erysipelas and sometimes puerperal fever, and each has the power of generating the other. A very striking illustration of the less usual of these reciprocal influences is related by this author:—

A fatal epidemic of puerperal fever occurred in the lying-in ward of a general hospital. After a time, the remaining and incoming women who were about to be confined, were transferred to a remote ward, which, until then, had been used for patients with diseases of the skin, while the latter were moved into the late obstetrical ward, after it had been thoroughly cleansed. Thenceforth the puerperal fever ceased, but a grave epidemic of erysipelas broke out among the new tenants of the obstetrical ward, attacking them without regard to the nature of their cutaneous disease, their constitution, or their general health.

An analogous illustration is furnished by Trousseau.[1] An epidemic of puerperal fever desolated the Maternity Hospital, and, when the authorities felt compelled to remove the pregnant women to other hospitals to be confined, erysipelas there broke out in a severe form in a great many of the surgical services, among those who had wounds.

It is worthy of remark that in certain epidemics of erysipelas, and notably in that of Paris in 1861, to which reference has just been made, a morbid change in the blood was manifested by certain prevalent disorders. Gangrene frequently occurred, which was apparently not produced by, or proportionate to, the tension of the erysipelatous skin; and, in like manner, boils and carbuncles formed, which were not at all confined to the seats of erysipelas, and which, therefore, must have originated in a special condition of the blood. A further and still more curious fact in this relation, is that many persons suffered from such affections who had not erysipelas, although they frequently occupied the same house or lodging with those who were laboring under that disease. It is of especial interest, also, that during this epidemic not only did puerperal fever prevail, but that in not a few cases pus formed in the articulations and in the serous cavities of the trunk.[2]

Retzius has given the history of puerperal fever as it occurred in the Lying-in Hospital of Stockholm. It began in 1858, and grew more severe in 1859 and 1860, so that the hospital became crowded, and, "as a consequence," it is stated, "erysipelatous inflammations soon manifested themselves, although no analogous disease existed in the town, and nothing in the condition of the individual patients afforded any explanation of their being attacked."[3]

The following instance illustrates the dependence of erysipelas and puerperal fever upon the same essential cause:—

Dr. Cox states that a physician having bled an erysipelatous patient, soon afterwards used the same lancet to bleed a man who had been hurt by a fall, and also a woman in labor. The man was attacked with phlebitis and the woman with puerperal fever.[4]

To pass over a period during which the instructive nature of these and many analogous instances, seems to have been forgotten or neglected, only one

[1] Lectures on Clinical Medicine, vol. ii.
[2] Dechambre, Gazette Hebdomadaire, Juillet, 1861, p. 476.
[3] Medical Times and Gazette, April, 1862, p. 383.
[4] American Medical Times, April, 1863, p. 198.

or two additional illustrations of the important truth they teach will be adduced. In 1877, Dr. Atthill[1] furnished the history of a local epidemic of erysipelas, which he summarized as follows: "Of ten (puerperal) patients admitted into a hospital, of which the sanitary condition had, previous to the admission of a case of erysipelas, been most excellent, nine were attacked with illness more or less severe, and one died; the only one who escaped being a case of abortion."

Dr. Thomas H. Buckler has stated[2] that "on three several occasions, during nine years, a single case of erysipelas admitted into the wards of the Baltimore City and County Almshouse Hospital, was the starting-point for the spread of its poison to all the medical and surgical wards to such a degree that the most trivial operations had to be avoided, and even the slightest scratch on the skin was likely to take on erysipelas, followed in some instances by phlebitis and pyæmia. At last the poison reached a lying-in ward, more remote than the others from the sources of infection, with invasion so fatal, that, after a time, for a woman to be delivered there was certain death."

Morbid Anatomy of Erysipelas.

The most prominent lesion of erysipelas is an exudative inflammation of the *skin*, which is usually seated in the thickness of the derm and in the subcutaneous connective tissue, but which is often confined to the layers of the skin immediately beneath the epidermis. The exudation is not merely sero-fibrinous; it contains a large number of *white corpuscles*, which have migrated through the walls of the bloodvessels. In cases which tend towards resolution, they disintegrate and are reduced to minute granular particles, which are then absorbed. Drs. Moxon and Goodhart[3] found in the blood of several persons affected with traumatic erysipelas, an increase in the proportion of white corpuscles; but in others this condition did not exist. Dr. W. Norton Whitney[4] states that in severe cases the proportion of the white corpuscles is increased; to one in fifteen in one case, and to one in thirty in another, and generally in proportion to the rise in temperature. In severe cases the *red corpuscles* run together, their edges are ill-defined, and they look like streams of yellow fluid crossing the field of the microscope. They also become more rapidly crenated than in healthy blood, showing a marked tendency, in severe cases, and especially when the temperature is high, to adhere to one another in masses, and not in rolls. In a case of Kollman, of Leipsic,[5] in which repeated hemorrhages from the bowels took place, fatally exhausting the patient, it is probable that such blood-changes existed in a high degree. To them also may be attributed the altered action of the heart, and the hæmic murmurs heard during life, and more immediately the fatty or granular change sometimes found in the cardiac muscles.

In 1862, it was related by Pihan-Dufeillay, that *enlargement of the spleen* occurred during the then recent epidemic at the St. Louis Hospital (Paris); and in 1873, Friedreich stated that in ordinary facial erysipelas he seldom looked in vain for enlargement of the spleen, adding that the organ frequently attained such a size as to project below the border of the ribs. He refers particularly to a case of floating spleen in which, during the progress of the erysipelatous attack, successive changes in the size of the organ could

[1] Obstetrical Journal of Great Britain, June, 1877.
[2] Boston Medical and Surgical Journal, October, 1880, p. 418.
[3] Guy's Hospital Reports, 3d s. vol. xx. p. 240.
[4] Inaugural Thesis, University of Pennsylvania, 1881.
[5] Archiv d. Heilkunde, Band xi., S. 398.

be accurately estimated. The tumor sometimes continued even for a fortnight after the subsidence of the febrile symptoms. This was particularly noticed in erysipelas of the scalp.[1]

Even in cases presenting brain symptoms, whether active or passive, no *cerebral lesions* corresponding to them are found; no exudation of lymph, and not even a large effusion of serum; but the veins, both of the meninges and of the brain, are sometimes engorged with blood. In erysipelas of the *throat and bronchia*, the mucous membrane of these parts is apt to be darkly congested and coated with tenacious mucus; occasionally ulcers are found upon it. They have also been met with in the *intestinal canal*. Larcher[2] met with them near the opening of the ductus communis into the duodenum, or on the opposite surface. The ulcers were about the size of a split pea, and did not penetrate the mucous coat. The analogy of these ulcers with those that have been found after burns of the skin, and also after scarlatina, is interesting. Malherbe[3] met with such ulcers in the jejunum and ileum; but they were not seated in the glands.

In many, if not in most cases, the *lymphatic vessels and glands* are inflamed, or at least structurally altered, and the *veins* may be the seat of a similar change. This may lead to coagulation of the blood in the veins (*thrombosis*), and the clots so formed may be carried into the vessels of the lungs, constituting *embolism* in those organs. Or the coagulation may obstruct an *artery*, and lead to gangrene of the parts beyond. Such accidents appear to be more frequent in persons of feeble constitution or impaired physical condition than in those of average health. The *local lesions* found in fatal cases of erysipelas consist of an infiltration of the connective tissue with a seropurulent fluid, which renders the parts soft and pulpy, and dissects out, as it were, the muscles, bloodvessels, and nerves. The parotid gland may be quite disorganized by purulent infiltration in cases of facial erysipelas, and the periosteum of the ramus of the lower jaw may be separated from the bone. The small muscles are often reduced to a pulp, and the lymphatic glands are enlarged and suppurating. Similar destructive effects are observed in cases of phlegmonous erysipelas of the extremities.

Symptoms of Erysipelas.

Like other diseases in which the local phenomena are subordinate, although essentially due, to a vice of the system, the first symptoms of erysipelas depend upon the condition of the blood. The material cause of the disease, circulating through the system, occasions phenomena analogous to those which introduce other febrile affections. These phenomena include general discomfort, muscular aching, pain in the head, loss of appetite, a chill, and, above all, nausea, with a bitter taste in the mouth, and vomiting, which is often bilious. Sometimes, a convulsion is among the earliest phenomena of the affection. The chill is apt to be prolonged and severe, and may often be taken as an indication of the gravity of the subsequent attack. It is followed by fever proportioned in severity to the chill, and the temperature may rise in a few hours to 104° F., or even higher. If the patient is already suffering from fever, these phenomena may not be present, or the rise of temperature may be unnoticed. The pulse becomes frequent, and is usually full and strong, especially in cases which are rapidly developed and in previously

[1] German Clinical Lectures, New Sydenham Society's edition, 2d series, p. 8.
[2] Archives générales de Médecine, Déc. 1864, p. 689.
[3] Ibid., Déc. 1865, p. 725.

healthy persons. The fever, however, usually presents a daily morning remission. The tongue becomes rapidly covered with a yellowish, thick, and pasty coating. Even yet the place of entrance of the poison into the system may betray no sign of its passage, while the lymphatic ganglia through which it has passed grow tender, swollen, and it may be red. In other cases, however, but in a relatively small number, the ganglionic inflammation appears later than the local evidences of erysipelas. It is important to observe that not only does the lymphatic tenderness and swelling, as a rule, precede the inflammation of the skin, but that it may even do so for several hours or even days. Indeed, an interval of three or even of six days has been observed between the two events. This familiar clinical fact disposes readily of the notion that erysipelas is merely a dermatitis, and that the constitutional symptoms are due to that inflammation and proportioned to its severity. They rather bear to the local affection a relation analogous to that between smallpox and inoculation, or between vaccinia and vaccination.

In the part about to be invaded by erysipelas, a sense of tightness is first perceived, accompanied with itching and burning heat, and followed by a steady pain which grows worse at night and when the skin is touched. At the same time, or soon after the pain is felt, usually in from one to three days after the occurrence of the initial symptoms, a blush appears upon the skin, and gradually deepens from a rose to a deep crimson color, or, in cases of a low type, to a still darker shade, while it extends in every direction around the point of origin; and in the same degree the skin swells, grows tense, smooth, and shining, and the redness and swelling, whether presenting a curved or an angular outline, are bounded by an abrupt elevation or ridge which can be both seen and felt as they tend to invade more and more of the sound skin. In persons of fair complexion, the contrast between the inflamed and the adjacent sound skin is very striking, and the former gives to the finger an impression of roughness which is due to the distended papillæ of the derm, and to the minute vesicles which form upon its surface. The erysipelatous swelling is greatest where the subcutaneous connective tissue is most abundant, and, when it affects the face, the eyelids cannot be opened, the nostrils are obstructed, and even the jaws can be but slightly separated from one another. In no other disease, except smallpox, are the natural features so completely deformed. When a limb is involved, it is so heavy, stiff, and painful on motion, that it is instinctively kept at rest. The swollen part does not usually pit on pressure, but is tense and hard; but in certain sluggish forms of the disease the skin does not resist pressure, and has a boggy feel. Besides the face, the parts most liable to extreme swelling are the genital organs in either sex. The tendency of the inflammation is to extend, not always steadily and uniformly, but by fits and starts, and each new extension is accompanied with an increase of the fever. Nor does it usually spread equally in all directions from the place of starting, but generally tends from points on the extremities towards the trunk, and from the face towards the scalp; it may also pursue a linear path, or break out freshly at one or more remote points (*Wandering Erysipelas*). This is more common in surgical than in medical cases. In the latter, there is a very singular peculiarity relating to the point at which the inflammation commences. In the vast majority of cases, the eruption first appears at the root of the nose, and next in order upon the cheek or the ear. In old persons, especially such as have varicose veins, it is apt to attack the legs, but without presenting, as a rule, very acute phenomena. It has been remarked that the chin is very rarely involved, even in cases of erysipelas in which the eruption occupies the rest of the face and the scalp.

In surgical erysipelas, the local inflammation ordinarily and evidently begins at a wound, which always becomes dry, and of a dull color; but when the disease prevails in a hospital, some other part, and especially the face, may be the first to suffer. The general appearance of the eruption has already been described, but it may here be added that wherever it occurs, except upon the scalp, there may also be present true vesicles, phlyctenæ, or blebs, which are filled with a thin and milky serum in cases of moderate severity, but with a bloody or dark liquid in the typhoid form of the disease. This liquid sometimes escapes, and concretes into thin and dark brown crusts. In other cases, and probably from its excessive tension, the skin loses its vitality to a greater or less depth, and sloughs form, which may or may not involve the whole thickness of the integument. The blebs and the sloughs, in a greater degree, are apt to occur where the skin is delicate, as about the genital organs, and quite frequently on the eyelids. Blebs are not very uncommon upon the cheeks and even on the extremities. Such cases are not to be confounded with those of phlegmonous erysipelas, in which form there is less activity of the disease in the skin itself than underneath it. Nor are the limited abscesses which sometimes form beneath the skin, although tending to augment the fever, to be considered as constituting phlegmonous erysipelas.

Meanwhile the general symptoms become severe in the same proportion as the local phenomena. The temperature may reach or even exceed 105° F., by the third day; the pulse ranges from 100 to 120, and is only moderately full and strong, while the impulse of the heart and its first sound are relatively feeble; the patient suffers from headache, general distress, restlessness and sleeplessness, and is apt to be delirious, especially at night, and to be somnolent at other times. Irregular chills are experienced from time to time; the tongue is thickly coated; and, at the height of the attack, nausea, vomiting, and constipation, or diarrhœa, are not uncommon. At this period erysipelas manifests, even in cases of average severity, a tendency to assume the typhoid type, with a dry and brown tongue, tremulous movements, muttering delirium, and imperfect consciousness, while a small proportion of albumen may be detected in the urine. This tendency renders more intelligible the epidemic forms of the disease, in which from the beginning the same type prevails, clearly denoting the existence in the blood of a poison which primarily occasions the specific phenomena of erysipelas, and secondarily those which are everywhere characteristic of the typhoid state.

The temperature has more than once been alluded to, but demands a more particular description. The rise to 104° F. may take place within a few hours after the initial chill. Most frequently this temperature continues with but slight morning remissions as long as the inflammation continues to extend, or the evening exacerbation may be attended with a temperature of 105.8°–106.7° F., or, though rarely, 107.6° F., while the morning remission falls a little below 104° F., and occasionally below 102.2° F. The maximum temperature is not usually reached at the end of the fever, but one or two days earlier. Defervescence then follows, and generally, in the course of twelve hours, or in a single night, the temperature falls to the normal point, or very nearly so. Sometimes, however, this rapid subsidence does not occur, especially when the temperature has previously been very high, but one more exacerbation takes place in the evening, and the normal degree is not reached until the following night. Not unusually the defervescence is less rapid, and exhibits something of a remittent type, as in typhoid fever. This is most apt to occur when the inflammation of the skin subsides slowly, or still continues, but with diminished activity, to extend. Not infrequently, after an interval of from one to six days, and whether or not it has meanwhile become normal,

Fig. 8.

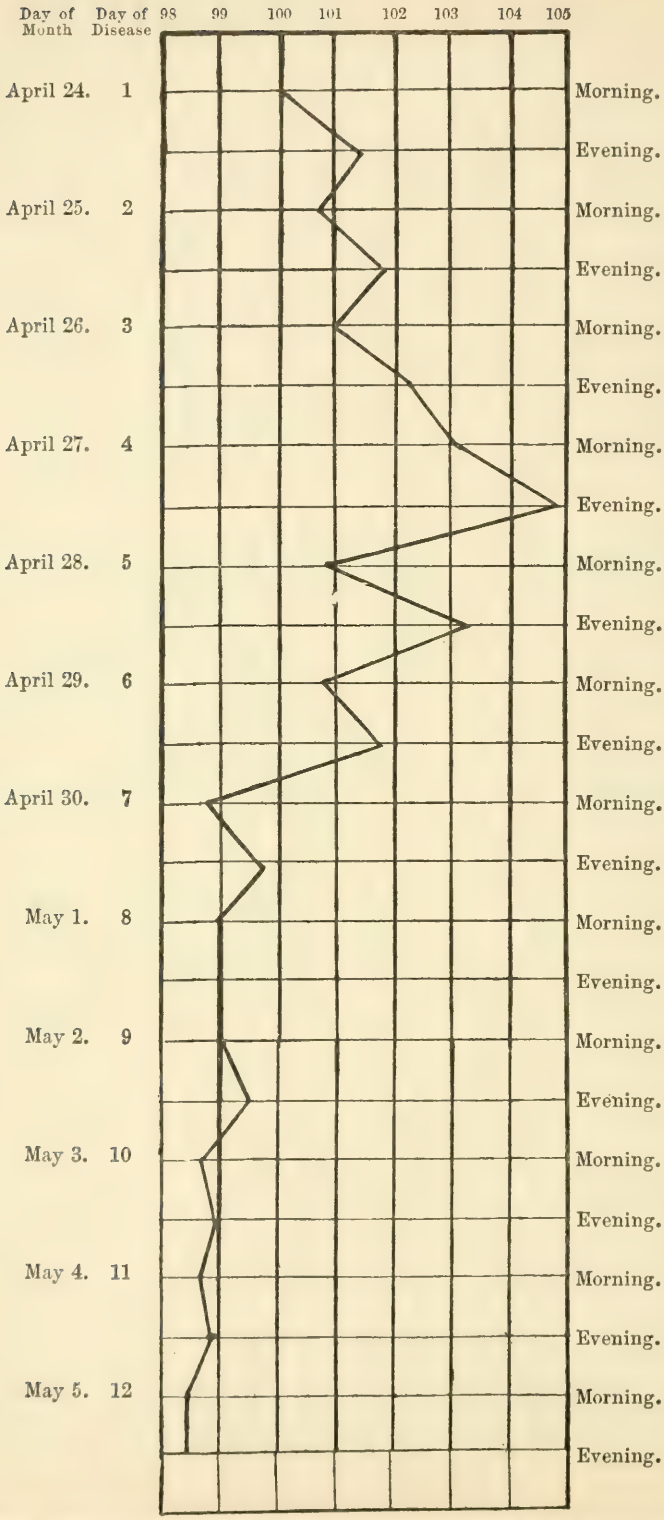


Chart showing variations of temperature in a mild case of facial erysipelas.

the temperature takes a sudden and striking rise, which either accompanies or announces a new extension of the erysipelas. The relapse, however, does not generally last as long as the original fever, indeed for only one or two days usually, but it may recur several times, especially in the erratic forms of erysipelas; nor does the fever finally subside until the eruption permanently disappears. When such relapses succeed one another, the fever declines with each one more and more, until with a very slight eruption it may become imperceptible. In fatal cases, death generally occurs with a high temperature (Wunderlich). The exacerbations and remissions now referred to appear to be in some manner inherent in the disease, or, at least, their exciting causes elude observation; but often the former can be traced to some imprudence in eating, some exposure to cold, or even to undue mental excitement. The accompanying diagram (Fig. 8) exhibits the changes of temperature in a mild case of facial erysipelas following lupus of long standing.

As the fever subsides, the hardness and tension grow less, and the skin pits more or less under pressure; the elevated ridge which abruptly bounded the inflammation, subsides, the redness becoming less vivid, and shading off gradually into the color of the sound skin. As the tissues shrink more and more towards their normal dimensions, the over-stretched epidermis becomes loosened, and is apt to be detached in large flakes, leaving the inflamed skin with a new cuticle, and with more or less of a red color, which it retains in some degree for many weeks. When repeated renewals of erysipelas occur in the same part, they may induce a thickening of the skin, and in the lower extremities are apt to occasion also a permanently bluish tint and an œdematous condition of the limbs.

The tendency of erysipelas in its simple form to recur again and again, and not only in attacks directly succeeding one another, but after an interval of months or years, presents one of the strongest contrasts between it and the eruptive fevers, with which in other respects its analogies are very close indeed. It is true, however, that the nature of most of these recurrent cases is open to question, and that not a few of them seem to have been instances of *erythema* rather than of erysipelas, or, as they have been called by Daudé, *erysipeloids*. Further remarks upon this point will be found in the section on Diagnosis.

The description which has now been given relates chiefly to erysipelas as it is observed in and confined to the skin; but when the inflammation extends to subjacent parts, the phenomena are different, and depend partly upon the nature and partly upon the extent of the process. In general, its extent is determined by its nature; that is to say, the more sthenic the inflammation, the more apt it is to be limited in extent; the more asthenic, the greater is the tendency of the inflammation to extend indefinitely. In the former case, the system is capable of establishing barriers of lymph, which circumscribe the inflammatory process; in the latter, this goes on unresisted, and may spread far and wide beneath the skin. Yet the very intensity of the local inflammation may destroy the vitality of the skin in a limited area, as has already been stated in regard to the eyelids and the organs of generation. In these cases, and generally at the height of the attack, spots of a darker red appear on the erysipelatous skin, which gradually grow livid and black, and ultimately separate as eschars. Or suppuration may occur beneath the skin, in consequence of the imperfect supply of blood in the part, as not uncommonly happens in erysipelas following wounds of the scalp. The abscesses referred to may be conjectured to take their rise in an inflammation and obstruction of the lymphatics leading from the primary seat of the erysipelas; they are seldom large, and do not materially affect the course

and issue of the primary affection. To them, rather than to the next form to be noticed, should the term "phlegmonous erysipelas" be properly applied.

Phlegmonous Erysipelas.—The affection usually described as *phlegmonous erysipelas* is an erysipelas which originates most frequently in wounds that involve both the skin and the subcutaneous connective tissue, and which tends to diffuse itself in the latter and on the former, without being limited by the formation of an inflammatory abscess. It issues in suppuration or gangrene, or both at once, and according to its degree and type is attended with inflammatory or typhoid phenomena. The onset of the attack generally presents in a high degree the premonitory symptoms which have been already described, and the part about to be affected feels tense and heavy. When the eruption appears, the skin is not of a uniform redness, but often darker streaks are visible along the lymphatic vessels, and the corresponding glands are enlarged and tender. The skin is very greatly swollen, hot and hard to the touch, and very painful. By degrees the tension and hardness diminish, and give place to a boggy softness, with abatement of the pain. Meanwhile, underneath the skin the congestion has been followed by an exudation of pus and a softening of the connective tissue, as well as of the cutis. Sooner or later the skin becomes eroded, or is opened by incision, and gives issue to a large quantity of thin and fetid pus, of a gray or brownish color, and mixed with shreds of dead connective tissue that have been aptly compared to "strings of wet tow," to "the membranes of a young fœtus," to "wads of wet chamois leather," etc. The destructive process is much more active in the subcutaneous connective tissue than in the skin itself; whence it often happens that the latter is to a great extent undermined, and between it and the muscles, and among the latter, vast cavities are formed. A case is related in which the whole integument of the abdomen thus became detached from the muscles, without, however, destroying the vitality of any portion of the skin (G. B. Wood); but more frequently the loosened skin mortifies, and vast ulcers result, which are difficult to heal, and often lead to permanent contraction of the denuded parts. The general symptoms are apt to be severe, and include high fever and delirium; and when suppuration sets in, there is usually a chill, followed by increased fever, and often by depression, prostration, hectic sweats, diarrhœa, wasting of the tissue, and, in a word, by all the phenomena of pyæmia, including, in some cases, metastatic abscesses. The examples of arthritis complicating erysipelas are probably of this nature.

Dr. John Ashhurst, Jr., has related[1] the case of a man who, without apparent cause, was attacked with erysipelas of the right lower extremity, accompanied with great swelling of the knee-joint. Although the general symptoms subsided, the joint remained enlarged for several weeks, and then gradually became smaller. Some weeks later the left knee began to swell, and subsequently an opening formed, through which pus was discharged to the amount of a pint at first, the discharge, however, not ceasing until the patient's death, which was hastened by bed-sores. After death, it was found that both knee-joints were distended with pus, that the cartilages had nearly disappeared, and that the ends of the thigh-bones were eroded.

It may be objected that in this case the arthritis was the primary, the erysipelas the secondary, affection, and, indeed, this objection has been made to analogous cases (Gosselin); but the suppuration of the joints observed in puerperal fever, and the close relation of the latter disease to erysipelas, render probable the direct dependence on the latter of certain cases of arthritis.

[1] American Journal of the Medical Sciences, July, 1865, p. 103.

According to Gosselin, an erysipelatous inflammation of the joints may either terminate by resolution without impairing the movements of the limb, or by suppuration, and in the latter case with all the possible consequences of such an arthritis from other causes.

Œdematous Erysipelas.—There is a degree, or variety, of phlegmonous erysipelas which has been described as the *œdematous;* it differs from the former in presenting far less active symptoms, and congestive rather than inflammatory. The color of the skin is not a bright, but a pale or dull, brownish red; the swelling is smooth and shining, and pits but slightly and momentarily on pressure. When incised or punctured, bloody serum flows out. It occupies the same seats as idiopathic erysipelas in general, and does not frequently accompany the traumatic form.

Gangrenous Erysipelas.—Of *gangrenous erysipelas* it may be remarked, in addition to what has been said above, that it is oftenest met with among the old and feeble, or persons exhausted by intemperance or disease, and in the cachetic infants of scrofulous or syphilitic parents. It is rarely primary, but usually arises in the course of some other affection. The color of the skin is a dusky red, which does not disappear under pressure; its heat is not great, nor is the pain, and the swelling is doughy and circumscribed. Phlyctenæ form upon the inflamed skin, and discharge a thin and offensive serum, and such parts are apt to slough, especially where the skin is delicate. In this way considerable portions of the scrotum have been lost, and cases are recorded in which this covering was entirely destroyed and the testicles exposed, but which, nevertheless, ended in recovery. In other cases, attended with high fever and other grave symptoms, and, according to Gosselin, between the fifth and the tenth day, or even later, there appear upon the erysipelatous surface, and sometimes quite at its limit, one or several dark spots, which are moist, insensible, and cold, and from which the cuticle presently separates with or without the previous formation of phlyctenæ. At the same time the fever becomes more intense, the tongue grows dry, the strength fails, and gradually the patient sinks, and almost invariably dies. Of these different degrees or forms of gangrene affecting the skin, one appears to depend upon the relative intensity of the inflammation as compared with the resisting power of the tissue involved, while the other seems to be more especially associated with that typhoid condition which everywhere implies an impaired vitality of the tissues.

Howard Marsh[1] describes an erysipelatous inflammation of the scrotum and penis, which also involves the surrounding parts. It may arise either as a primary affection, and is met with as such chiefly in persons above middle age, whose health is reduced in many instances by advanced kidney-disease, or may depend upon some local condition in which the original mischief was deep-seated abscess of the perineum. It was described by Liston as "inflammatory œdema," and that surgeon declared that in Edinburgh he had had no less than six cases under his care during a very wet and unhealthy season. Mr. Holmes has particularly pointed out that the retention of urine which is apt to occur should be regarded as the effect, and not the cause, of the erysipelatous swelling of the scrotum. Hence the importance of determining, if possible, whether an urethral obstruction existed before the erysipelas, and also the actual condition of the canal. If a catheter can be passed readily, it is evident that the urethra is not strictured, and that, consequently, there is no need of retaining in it an instrument, which would only aggravate the

[1] Medical Times and Gazette, September 30, 1865, p. 363.

renal and vesical disease which is generally present. In regard to the treatment of the swelling itself, it may be mentioned, in passing, that it has been usual to make free incisions into the distended parts.

In 1791, Dr. Percival, of Manchester, England, described a peculiar affection of the vulva in a girl five years old; and in 1815, Mr. Kinder Wood related the history of twelve similar cases that had occurred in his own practice. Like erysipelas, it usually had prodromes of two or three days' duration, when the difficulty of passing water drew attention to the genitals of the little patients. It was then found that the labia first became swollen, and afterwards inflamed, blistered and ulcerated, while the inflammation extended to the thighs. There was no spontaneous tendency to gangrene.[1] The reporter of the cases discusses the question whether this disease was erysipelatous, and decides in the negative; but the analogies of the affection with erysipelas render some notice of it in this place appropriate.

Erysipelas of the Face and Scalp.—Of the local and external varieties of the disease, erysipelas of the *face*, and that of the *scalp*, demand a few special remarks. The former affection is by far the most common form of the disease unconnected with surgical affections. Preceded by the general phenomena already described, the eruption usually makes its appearance upon the bridge of the nose, in which case it almost always spreads symmetrically to either side, involving by turns the eyelids, the nose, the forehead, the ears, the cheeks, and the upper lip, but usually stopping at the junction of the skin of the forehead with the hairy scalp. It does not often descend beyond the middle of the neck. Sometimes it begins on one side of the nose, and, indeed, Mr. Bird[2] affirms that its starting point is most frequently the right side of the face. Not uncommonly it first affects one ear. Each of these cases is adduced in favor of the doctrine that the idiopathic disease always takes its rise from a direct infection; and in these instances it is held that the first impression of the poison is upon the nasal and pharyngeal membranes, whence its effects extend through the lachrymal canal to the face, or through the Eustachian tube to the ear. As the inflammation spreads over the face, the skin is at first of a scarlet, and then of a crimson or almost purplish color, and its surface is tense and shining. The ears especially are dark red. The swollen eyelids close the eyes, and obliterate entirely the depressions of the orbits, while from between them tears flow abundantly; the tumid nose and lips complete the disfigurement, and no trace of the natural expression of the face is left. The deformity is exaggerated when the scalp is involved as well as the face, and not only is the pain singularly increased by the unyielding nature of this integument, but cerebral symptoms of excitement or stupor are often present. The swelling of the ears renders hearing dull, and the obstruction of the nostrils compels the patient to breathe through the mouth. Very commonly phlyctenæ form upon the cheeks, and their escaping contents are apt to irritate the skin.

Erichsen[3] lays much stress on the fact that the erysipelas which is so apt to follow injuries of the scalp, seldom arises unless the tendon of the occipito-frontalis muscle is divided. In that case, the products of inflammation accumulate between the pericranium and the bone, causing a cellulitis with profuse suppuration, the pus from which undergoes putrefaction and sets up erysipelas. This surgeon denies that a wound of the scalp, or the use of sutures in treating it, has any special tendency to induce erysipelas, which

[1] Medico-Chirurgical Transactions, vol. vii. p. 84.
[2] Ranking's Abstract, No. xxix. 1859, p. 85.
[3] Lancet, January, 1878, p. 115.

he attributes exclusively to the retention and putrefaction of the exudations beneath the integument. Hence he condemns all dressings which tend to retain the discharges within such wounds. It is of importance to note that in this as in all other forms of traumatic erysipelas, the general precede the local symptoms. After a chill, followed by fever, the wound becomes dry and painful, and begins to be surrounded by an erysipelatous blush.

In erysipelas of the face, as in other forms of erysipelas, the general symptoms vary with the existing type, from sthenic to adynamic, but as this form more frequently than others affects persons previously in good health, its type is, on the whole, sthenic, and its issue favorable. The extension of the inflammation to the scalp is doubly inauspicious, for it not only denotes an inability to prevent the spread of the disease, but directly aggravates it by giving rise to derangements of the brain functions. Although delirium is apt to occur in erysipelas of the face, it is much more marked in that of the scalp, when it is usually low and muttering, though occasionally maniacal. In all forms of erysipelas, however, provided that the temperature is high, there is more or less tendency to delirium. At night it is of common occurrence, even when the eruption is confined to the face. It does not arise from inflammation of the brain or its meninges, for after death, in cases presenting this symptom even in an aggravated degree, no inflammatory exudation has ever been found within the cranium, and not even venous congestion uniformly. The delirium and coma preceding the fatal issue of the disease must therefore be attributed either to congestion of the brain or to an altered condition of the blood, or to both of these causes together. Many years ago (1860), Todd combated the prevalent idea that the cerebral symptoms of erysipelas were produced by a lesion of the brain, and explained them by the circulation of noxious blood through that organ. On the whole, we may fairly conclude that congestion has a share in producing the brain symptoms, because they are more frequent in erysipelas of the scalp than in that of any other part; but that the blood lesion shares in their production is denoted by the occurrence of coma in the puerperal and other forms of epidemic erysipelas, in connection with gangrene and evidences of blood-poisoning.

Many writers have attached importance to the gastric derangements in this form of erysipelas, and have described vomiting, and especially bilious vomiting, as quite characteristic of it. The symptom does indeed often occur, but perhaps is quite as often wanting. There is less reason for supposing that it is occasioned by any special disorder of the stomach or liver, than for regarding it as a sympathetic phenomenon due either to the altered quantity or to the quality of the blood circulating in the brain.

The duration of erysipelas of the face, especially when idiopathic, may be stated at from one to two weeks; but this may be greatly exceeded when the disease involves the scalp, or becomes phlegmonous. This form of the disease is perhaps less liable than others to relapses. Besides the sequelæ common to all the forms, there is one that is indeed rare and seems peculiar to erysipelas of the face. It is blindness, due to an atrophic degeneration of the optic papilla, which sometimes affects only one eye, and sometimes both eyes. The impairment of sight when it occurs only in one eye, begins towards the close of the attack, or when the swelling of the eyelids has subsided sufficiently to permit them to be raised. When both eyes have been involved, the impairment of sight appears not to have been noticed before the complete subsidence of the erysipelas, and, after varying in degree, to have left a permanent defect of vision, sometimes, however, in regard only to certain colors.[1]

[1] Parinaud, Archives Générales de Médecine, Juin, 1879, p. 641.

A quite unusual seat of the eruption presented itself in a case of Steiner's.[1] In a child two years of age, without known cause, the disease attacked simultaneously both thighs, and then extended to the feet. After it declined there a relapse occurred, the eruption appeared upon the trunk, and the child died.

Bilious Erysipelas.—The bilious phenomena above alluded to have such a predominance in certain instances, that to cases presenting them has been applied the title *bilious erysipelas.* The cases now alluded to occur in localities and at seasons in which a malarial influence prevails, and they are marked by bilious eructation and vomiting, bitterness of the mouth, a yellow tongue, epigastric uneasiness and tenderness, great thirst, sometimes constipation, or, again, bilious diarrhœa, scanty and yellow urine, and yellowness of the skin or conjunctivæ.

Metastatic Erysipelas.—Erysipelas is said to be *metastatic*, when it disappears abruptly from one place to reappear as suddenly in some other part. Thus it may pass from the face to the external genital organs, from the ear to the limbs, from the skin to some internal part, etc. This translation is sometimes produced by cold air, or by the application of cold or astringent lotions. Such phenomena illustrate the doctrine that erysipelas is not a local inflammation, but a disease involving the whole system, just as analogous metastases show a similar nature in gout and rheumatism. The change of seat, moreover, does not always take place abruptly; an internal organ may be attacked after the complete resolution of the original inflammation, presenting, in fact, the characters of a relapse in which the seat of the secondary is quite different in its character from that of the primary affection. For example:—

A young and healthy man experienced an attack of erysipelas of the face and scalp, which ran the usual, and a favorable course, even to desquamation. After six days of apparent convalescence, the patient was attacked with pain in the right side of the chest, cough, fever, sore throat, redness of the fauces, and crepitant rales at the base of the right lung. Death occurred in four days, when the pharynx was found of a bright red color which ceased abruptly at the œsophagus, but extended into the larynx, trachea, and right bronchus, even to its smallest subdivisions, though it did not affect the left. The alveoli of the right lung were distended with leucocytes, but there were no bronchial casts, nor did any hepatization exist. The nature of the exudation was characteristic of erysipelatous, but not of "croupous" or fibrinous inflammation. The disease, in this case, appears to have made two separate and independent attacks; but whether the poison that occasioned the second was the same that produced the first, and afterwards remained quiescent in the system, or whether the relapse was due to a fresh infection, may remain in doubt, the former view, however, seeming to be the more probable.

Erysipelas of New-born Infants.—Erysipelas in *new-born children*, at least in its epidemic form, is, as was long ago observed, almost entirely confined to lying-in hospitals. It was doubted by Underwood whether it ever affected those who were more than a month old, but, unless those cases alone are regarded which originate in section of the umbilical cord, this opinion is too exclusive. The disease sometimes prevails among children of one or two years, confined in hospitals. On the other hand, it is known to have occurred during intra-uterine life, as in Bromfield's[2] case, in which the child was born with erysipelas of the face and legs, and in which, although sloughs existed on the latter at birth, recovery followed. In nearly all cases of this form,

[1] Prager Vierteljahrschrift, Bd. lxxxix. Anal. S. 67.
[2] Medical Communications, vol. ii. p. 22.

the erysipelas is distinctly traumatic, and takes its starting-point from the divided umbilical cord; but it as distinctly coincides with epidemics of puerperal fever, and must be attributed to the same essential cause as that affection. Trousseau, at an early period of his career, pointed out this relationship between the two diseases, and in 1855, Lorain stated that under the same conditions infants also perished with peritonitis, abscesses, septicæmia, and gangrene of the limbs, and that in the greater number of such cases the mothers had died of puerperal fever. Nunneley followed Underwood in noting the extremely sudden onset and rapid development of the inflammation, and Trousseau insisted upon the same point, and also upon the almost inevitable fatality of the disease within the first two or three weeks after birth.[1] It generally begins to show itself at the pubes, extending rapidly upward on the abdomen, and downward upon the thighs and genitals, which grow exceedingly red, swollen, hard, and œdematous, and then purplish; phlyctenæ form, and the skin is attacked with gangrene. The infant at the same time falls into a state of prostration, yet has scarcely any fever at first; but as the inflammation spreads and grows more intense, fever comes on with pain, and there is great restlessness, sleeplessness, and debility, with vomiting and diarrhœa, which rapidly exhaust the strength and bring on a fatal issue from the fifth to the seventh day. This termination is sometimes due to gangrene of the erysipelatous parts, and sometimes to the formation of abscesses, although, according to Trousseau, the latter occurrence is, on the whole, a favorable sign.

Erysipelatous Peritonitis.—This form of erysipelas was first described in 1828, by Abercrombie,[2] who alludes to its symptoms as being sometimes slight and insidious, though sometimes very severe, but as chiefly distinguished by the rapidity with which they run their course, and by a remarkable sinking of the vital powers, which occurs from an early period, and often prevents the adoption of any active treatment. In one of the cases related by this author, an erysipelas of the leg abruptly subsided, the patient was seized with symptoms of peritonitis, and died in a little more than twenty-four hours from the time of the attack. In another case, the primary attack was an erysipelas of the throat, but during convalescence the patient was suddenly seized with violent pains in the abdomen, followed by collapse and death in about forty-eight hours from the commencement. In the Merchants' Hospital (a charitable institution for the education of girls), and while an epidemic of erysipelas of the throat prevailed in Edinburgh, a number of the inmates were attacked with the disease in a similar form; but, after a week, one of the girls who seemed to be entering on convalescence, was suddenly seized with symptoms of peritonitis, including vomiting, diarrhœa, pain, and collapse, of which in a few hours she died. A second fatal case occurred with nearly identical symptoms; and in both of them inspection after death revealed the lesions of peritonitis, including an exudation which was puriform rather than fibrinous. Abercrombie makes the following commentary: "This affection differs from the usual forms of peritonitis; and, without speculating further upon the nature of it, we may add that its alliance to erysipelas appears to be an obvious and remarkable character of the disease."

[1] Lectures on Clinical Medicine, New Sydenham Society's edition, vol. ii. p. 271.
[2] Pathological and Practical Researches, etc., p. 181.

Diagnosis of Erysipelas.

The direct or positive diagnosis of erysipelas may frequently be made before the actual appearance of the eruption upon the skin or adjacent mucous membrane. It rests primarily upon the swelling, redness, and tenderness of the lymphatic glands connected with the part about to be attacked. Those of the neck usually present such appearances in erysipelas of the face or throat; those of the axilla or the groin, in erysipelas of the upper or lower extremities. When the inflammation itself appears, it may be recognized by the uniform pink or rose color of the skin, which in the throat assumes a dusky hue; by the rapid swelling of the integument, accompanied with a burning heat of the part; and especially by the abrupt ridge that divides the inflamed from the unaffected skin, the rapid encroachment upon the latter of the inflammation, and the equally rapid rise of the temperature. These signs distinguish erysipelas from *lymphangeitis* or *angeioleucitis*, in which the swelling is less, and the redness, instead of being uniform, follows the trunks of the lymphatics, and is therefore streaked, and also presents limited and indurated swellings, and is not abruptly bounded by the sound skin. It does not follow, however, that the two affections may not coexist in the same case. *Erythema*, such as is at all likely to be confounded with erysipelas, is a much more superficial inflammation of the skin, and its edges are not abrupt and elevated as in the other disease. When it occurs, as it often does, upon œdematous or dropsical parts, this sign is distinctive, especially as the affection is not attended with the febrile movement which accompanies erysipelas. When it is traumatic, it is more apt to arise from abrasions, from friction, etc., than from a division of the tissues. Yet it is not uncommon around certain more deeply seated lesions, such as old ulcers, especially of the legs.

Volkmann has directed attention to the difficulty of distinguishing from phlegmonous erysipelas, a diffused inflammation of the connective tissue which results from severe injuries, and which presents an irregular and often dull redness and an œdematous swelling of the skin. He notes as distinctive marks of this affection, a slow development of fever, with a relatively rapid appearance of bluish-red or dusky, venous congestion, a doughy state of the swelling, and a peculiar sanious or gangrenous aspect of the original wound, while the general condition of the patient does not present any grave disorder. It is to these contrasts, in a particular case, that Erichsen probably alludes when he speaks of the difficulty of distinguishing between abscess of the scalp and erysipelas.[1] But while in both there may be fluctuation, it is in abscess always limited by the attachments of the occipito-frontalis muscle to the occipital ridge and the zygoma, while in front the pus will be apt to gravitate towards the eyes, and form a puffy swelling of the eyelids. But in diffused erysipelas of the scalp, the ears are always involved, and become red, swollen, and covered with blebs.

Prognosis of Erysipelas.

The prognosis of erysipelas varies, according to the character of the attack, from almost absolute safety to as absolute fatality. The former estimate refers to the idiopathic, sporadic disease, the latter to the epidemic puerperal form. Between these two extremes lie the large number of cases of surgical erysipelas in which the mortality fluctuates indefinitely, and chiefly with the dominant type of the disease.

[1] Lancet, January, 1878, p. 115.

First, in regard to medical erysipelas occurring primarily and confined to the skin, the prognosis is generally favorable. One of the greatest of French clinicians, Chomel, declared that he had never seen a fatal case of primary erysipelas of the face; and Trousseau, whose immense experience gives his statement great weight in such a matter, stated that of the large number of cases of this affection which he had seen, not more than three had proved fatal. During a period of four years he met with but one death in fifty-seven hospital cases, and in it the hairy scalp was involved. Indeed, he was disposed to regard this most ordinary form of the disease as benignant in its character, and even less fatal than bronchitis; and he charged that where recoveries had taken place after the use of bleeding or purging, or the employment of emetics, blisters, or cauterizations, they had occurred not in consequence of the treatment, but in spite of it.[1] Our own experience coincides perfectly with this, for we have never yet met with a fatal case of primary, idiopathic erysipelas of the face in hospital or in private practice, where the disease was submitted to a palliative or a supporting treatment. But we have seen it fatal under the use of evacuant, sedative, and so-called alterative measures.

If, however, we take all the accessible reports of the mortality from idiopathic erysipelas of the skin, which have emanated from hospitals, especially in Europe, a different result is obtained. For instance, in the Parisian hospitals, in 1862, there occurred 759 cases of various forms of non-traumatic erysipelas. Of these, nearly 17 per cent. terminated fatally, while in the following year the mortality was only 8.5 per cent. In still stronger contrast with the usual mortality of the disease, as it is seen in this country, the further statement may be made that during the two periods just mentioned, in Paris, the mortality of surgical erysipelas was, for the former, nearly 78 per cent., and for the latter nearly 77 per cent. In this country no such lamentable results have ever been observed, not even during our civil war.

It has been stated elsewhere that erysipelas occurring within the first month of life, is nearly always fatal; but once this period is passed, the issue of the disease depends upon the same general conditions as in the case of older persons, and especially upon the original vigor of the patient, and the appropriateness of the hygienic and medicinal treatment.

It is proper to state once more, what has been already mentioned, that the decline of an attack of erysipelas of the skin is always to be expected when the inflamed area shades off gradually into the sound skin; while, as long as it is abrupt, a further extension may be looked for. But even after the complete subsidence of the inflammation, a relapse may take place, and in some persons the attack recurs repeatedly, even after long intervals. It appears that this tendency has been exaggerated by confounding together erythema and erysipelas. However this may be, the liability of erysipelas to relapse is most apt to be exhibited in hospitals and other places where a number of cases of the disease have been brought together. In his account of one hospital epidemic, Miller states[2] that out of twenty cases, six suffered relapse, four of them once, one of them twice, and one five times; and that on almost every occasion the fresh attack could be traced to infection by a newly admitted patient. According to Gosselin,[3] the secondary eruption usually occupies the same seat as the primary, extends more rapidly than it, runs its course in a shorter time, and always ends in cure.

Erysipelas commencing distinctly in the *fauces*, or invading them by exten-

[1] Clinical Medicine, vol. ii. p. 263.
[2] Edinburgh Medical Journal, vol. xxv. p. 1095.
[3] Dictionnaire de Médecine et de Chirurgie Pratiques, t. xiv. p. 25.

sion from the face, or extending to the *air passages* or to the *brain*, from the throat or from the scalp, always involves danger. *Phlegmonous* and *gangrenous erysipelas* are dangerous in proportion to their extent, and to their tendency to spread without limit. Suppuration in the form of abscesses involves no special danger. As a common exciting cause of traumatic erysipelas is *alcoholic intemperance*, so does this habit also render the issue of the disease less favorable; it tends to favor the extension of the inflammation, and to increase the risk of suppuration and gangrene, as well as to bring about that typhoid state of the system which constitutes one of the greatest dangers of erysipelas. *Erratic erysipelas* is not severe in itself at any one time, but by its recurrence and its duration for many weeks, or even months, may gradually exhaust the patient's strength.

In the *epidemic* form of erysipelas, and in those local outbreaks of the disease which sometimes assume an equally low type, the danger of death is great in proportion to the degree in which the typhoid state is exhibited, due regard being had to the original soundness and vigor of the patient. When the disease is confined to the throat, or when it also attacks the skin, the disease is seldom fatal, unless it acquire a phlegmonous character in the former situation. This is especially true of cases in private practice. The most fatal form of erysipelas is that which attacks internal organs, and especially the *lungs* and *peritoneum*. In both cases the hope of recovery is very small; but in puerperal peritonitis of erysipelatous origin the mortality is almost absolute, and the rapidity of the fatal course is often as appalling as its issue is inevitable.

In general terms, the conditions that increase the danger of erysipelas are such as involve debility, including infancy, old age, and complication by previously existing or concomitant diseases, such as phthisis, Bright's disease, diphtheria, or the eruptive and typhous fevers. Moreover, death has occurred by hemorrhage from the bowels in a case which was otherwise benign, and in which no lesion could be found to account for the accident.[1] Finally, blindness has been known to result from erysipelas of the face, as in the case of Despagnet.[2]

Prophylaxis of Erysipelas.

The measures which it is advisable to adopt for the prevention of erysipelas may readily be inferred from the description of the causes heretofore given. They may all be included in the following rules:—

I. The utmost purity of the air should be preserved in all apartments habitually used by day, or for sleeping, and especially in hospital wards and other places occupied by the sick.

II. All patients suffering from erysipelas should be isolated, and nothing that has been used by or for them, and, least of all, surgical instruments, should be employed for non-erysipelatous patients. On the same principle, in climates and seasons which make it possible to treat the wounded in tents or in temporary wooden hospitals, such as were used during our civil war, the danger of erysipelas is reduced to a minimum by doing so.

III. On no account should a puerperal patient be confined in a house infected with erysipelas, nor be attended by any physician who has recently had charge of an erysipelatous case.

IV. A surgical ward should never be in close proximity to a lying-in ward,

[1] Archiv der Heilkunde, Bd. xi. S. 398.

[2] Recueil d'Ophthalmologie, Paris, 1880.

nor even in the same building, and the attendants in one should hold no communication with those of the other.

V. During general or local epidemics of erysipelas, all cutting operations should be, if possible, avoided, it being remembered that the danger of the erysipelatous infection of wounds is in direct proportion to their extent.

VI. For the reason just mentioned, it is held by some surgeons that subcutaneous incisions should, under such circumstances, be preferred, and that the surface of recent wounds should be protected by a nitrate of silver film.

Treatment of Erysipelas.

The most ancient treatment of erysipelas, as described by Hippocrates, consisted in the application of cold water, provided that no ulceration of the skin existed.[1] According to Paul of Ægina,[2] if the patient's strength permit, blood-letting and cholagogue medicines should be employed, with the topical use of ointments overlaid with cooling lotions. This writer also recommends emollient poultices made from various mucilaginous plants, with the addition of anodynes, and, at a later stage of the disease, cooling or astringent applications, some of the former containing vinegar, and some of the latter saturnine solutions, potter's clay, and various astringents, including copperas and alum. He also refers to the necessity of incising the skin when mortification threatens (a recommendation made also by Galen and his successors), and speaks of the virtues of hot or salt water in chronic states of the affection. It is worthy of remark that he and nearly all medical authors from the most ancient times, dissuade from depletion in this disease, although some Arabian authors are exceptions to this statement. Another point upon which there is a general agreement, is the administration of certain purgatives supposed to be cholagogue. Whether this practice rested on the fact that epidemic erysipelas was apt to be attended with jaundice, or upon the authority of Galen, who enjoined it upon grounds that now seem quite futile, it is unnecessary to inquire. Beyond a doubt, the practice itself is good at the commencement of an attack, especially when it is associated with the use of emetics, which the ancients do not appear to have employed in this disease. Celsus[3] gives the same qualified advice respecting venesection, and directs the use of cooling and astringent applications, especially ceruse and solanum (dulcamara?), or chalk. He adds that whatever topical remedies are used, should be applied cold, and kept covered to prevent their getting dry. But he is by no means prejudiced in favor of this refrigerant method, for he enjoins, if its effects should not be favorable, that stimulants and astringents infused in wine should be substituted for it, and, if the part should still remain indurated, that anodyne ointments and cataplasms should be applied.

The history of erysipelas illustrates the general truth in therapeutics, that modes of treatment, and especially of acute febrile affections, should be determined by their type, rather than by their essential nature. In a large number of cases, it is so far local and superficial that its treatment may be confided to protectives and palliatives; in many more, an active antiphlogistic method will be tolerated, even if not really indicated; but in a still more numerous class, and especially during epidemics, whether nosocomial or more widely spread, and whether idiopathic and primary or puerperal or traumatic, a general treatment at once stimulant, supporting, and tonic, is the only one from which favorable results can be expected. In this disease, as in

[1] Works, Sydenham Society's edition, vol. ii. p. 741.
[2] Sydenham Society's edition, vol. ii. p. 66.
[3] Lib. v. cap. xxvi. sect. 33.

all that tend to assume a typhoid type, the sagacity of a physician is displayed less in the general plan of treatment he pursues, than in the modifications by which he adapts it to the peculiarities of individual cases. He will keep constantly in mind that he is not treating an abstract disease with abstract remedies, but human beings, whose health or life may depend upon his use of agents that may be mischievous or salutary, according to the manner in which they are employed.

In no disease more than in erysipelas, have greater errors been committed by overlooking its natural history. Internal medicines, the most diverse in their nature and the most opposite in their effects, have, at different times, or by different physicians, been equally vaunted as cures for this disease. At one time depletion, at another stimulants, now sedatives, and now tonics, have been in vogue, while external applications, as opposite to one another as oil or mucilage, on the one hand, and mercury, iron, and nitrate of silver, on the other, have alike enjoyed a temporary or local favor. One acquainted with the history of therapeutics must regard the claims constantly and confidently put forward in favor of successive remedies, as exhibiting a very insufficient acquaintance either with this particular disease or with the laws which should govern the search after truth. The instructed pathologist and therapeutist knows that the majority of the cases of acute disease tend, under favorable circumstances, to recovery, and therefore require only a palliative and expectant treatment; and he also knows that under exceptional circumstances, as during certain epidemics, death is the necessary end of most of the cases. Only on the middle ground between these two extremes is it that the physician is of much avail to determine the issue; at either extreme his influence is limited to smoothing the way to death, or rendering easier and more pleasant a return to health. To abstain from interference when it is needless, is as high a duty as to interfere when it is necessary, and rightly to judge how far the intervention should proceed. It may be laid down as the law of non-epidemic erysipelas in general, when it occurs in a previously healthy person, and is not complicated with septicæmia in traumatic cases, that it tends spontaneously to recovery; and that in simple, or so-called idiopathic cases, such a result may be looked for within a week. Even if it be possible to shorten this duration by the use of certain medicines, the gain is a gain of time rather than of life over death.

Such is the verdict of experience, and no ingenuity of scientific pleading can set it aside. "When," said Trousseau, "a patient suffering from erysipelas is placed under my care, my rule is to abstain from every kind of treatment," and he adds that such had been his plan for twenty-eight years, and that, thanks to it, he could not remember losing more than three persons from erysipelas during that period. He insisted on the importance of keeping patients in bed, both in the acute stage and during convalescence, to prevent their catching cold and suffering relapse; he prescribed acidulated drinks, laxatives if the bowels were confined, and purgatives if the vomiting were violent. But he insisted also on the necessity of giving food, in spite of fever and even of delirium, and of avoiding whatever would debilitate, such as low diet, depletion, purgation, or the use of sedatives. In a like spirit with Trousseau, that very accomplished English physician, Latham, said "erysipelas is a disease that may be treated, but not cured;"[1] and Gosselin, the eminent French surgeon, declares that "erysipelas can be arrested by no treatment whatever."[2]

In ordinary cases, then, of erysipelas, that is to say, in cases of average

[1] Works, New Sydenham Society's edition, vol. ii. p. 461.
[2] Nouveau Dictionnaire, t. xiv. p. 30.

severity, and whether of the medical or the surgical form, it is imperative that the patient should, as far as possible, be isolated; that he should have no more attendants than are absolutely necessary; that his chamber should be well ventilated, but without exposing him to draughts of air or to dampness; that perfect cleanliness should be maintained about the wound, if there be one; and that when the bed- and body-clothing are washed, they should be thoroughly scalded before being handled. The inflamed part should be placed in as comfortable a position as possible, and the face, when affected, should not be exposed to a strong light; the skin should be kept dusted with lycopodium, or finely powdered starch, or wheat or rye flour, and covered with carded cotton; and in cases attended with much burning and tension, a smaller or larger proportion of oxide of zinc should be mixed with the flour, or the part may be kept anointed with vaseline, a far better protective than glycerine which has been much used for this purpose. Vaseline is also greatly superior to ointments, for unlike them it is not apt to become rancid, and it may serve as an excipient for oxide of zinc or lead, or any anodyne extract which may seem appropriate. The white of egg alone, or mixed with finely powdered alum, may also be used. Mucilages should never be employed. The mucilage of slippery elm, and still more of flaxseed, and poultices made of these substances, have to answer for a great deal of discomfort during their application, and the production of a vesicular or pustular eruption which is unsightly, painful, and sometimes difficult to heal.

At a time when every inflammation and fever was recognized as an almost infallible indication for *blood-letting*, it was naturally and extensively employed in the treatment of erysipelas, and its use was justified by names of unquestionable authority. Even the candid and clear-sighted Sydenham advised copious depletion. But the weight of judgment is on the opposite side. According to one, it is of "fatal tendency;" others "always found it hurtful," or "rarely admissible," or "destructive." "It makes bad worse," said Heberden; "it renders the disease more obstinate and severe," said Desault; and Willan declared that "in the low forms it is manifestly improper, and in the phlegmonous not always necessary." According to Copland, "large depletions should be employed with much circumspection, for however high the temperature, or hard and bounding the pulse, there is always a disposition to asthenic vascular action and a deficiency of vital power;" and Bally is of opinion that "it tends to aggravate the symptoms, bring on and intensify delirium, and prolong the attack."

Yet, even half a century ago, there were found eminent surgeons to say, like Sir W. Lawrence, that, "as this affection resembles other inflammations, it must be treated upon the same principles. Venesection, local bleeding, purging, and low diet are the first measures, to which saline and diaphoretic medicines may be afterwards added. Vigorous treatment in the beginning will often cut the attack short." It is true that he qualified the rigor of this method by stating numerous exceptional cases in which it would be mischievous, and especially those of patients weakened by old age or previous disease, and he recognized its inappropriateness after the first stage of the attack. Since his time, depletion having gone out of fashion, even in the treatment of sthenic, inflammatory diseases, it has naturally come to be regarded as pernicious in those which, like erysipelas, tend so readily to a typhoid state. The judgments against depletion in this disease are therefore quoted, not because at the present time any one would probably be tempted to adopt it as a mode of treatment, but to serve as an argument in favor of the opposite method which is advocated in this article. The objections are measurably applicable to local as well as to general depletion. Indeed in the former, if less injury is risked by the loss of blood, much more danger is

incurred, through the wounds made by leeching or cupping, of infecting the system anew with the erysipelatous poison, and of creating a starting-point for suppuration or gangrene. Such objections are still weightier against punctures and scarifications employed to relieve the congestion of the skin in simple erysipelas, inasmuch as they form wounds which, besides this special risk, answer their purpose as depleting agents very imperfectly indeed. The use of incisions in the treatment of phlegmonous erysipelas has special objects which will be considered hereafter.

The most ancient treatment of erysipelas included, as has already been stated, the application of *cold water* and other lotions to the affected part, but the dangers of the method, recognized even then, are more generally acknowledged now. We cannot therefore commend the practice of Luecke, who, following the example of Hebra and others, advises the application of *ice* to the erysipelatous scalp, and declares that he did not lose a single patient out of a large number treated by him in this manner.[1] Whether the same result would not have been reached by him, as it has been by others, with a purely negative topical treatment, may well be questioned. Indeed, it may be remarked here, once for all, that apart from the surgical treatment of phlegmonous erysipelas, local applications have not the slightest influence upon the course or issue of the disease beyond that which they exert as protectives and palliatives. This influence should not be undervalued, but it ought not to be mistaken for a radical and curative action.

As palliatives, then, may be employed a variety of *astringent* and *stimulant applications*, all of which protect the inflamed part from the irritating action of the air, and either repress the vascular action in it or overcome the stagnation of the blood by quickening its circulation. Of the former description are lime-water liniment, alum curd, fresh or sour cream, solutions of the salts of lead and zinc, or of the chloride or the sulphate of iron, or some of these salts, and especially the oxide of zinc, in powder. In France, a popular prejudice regards all watery applications as injurious. The acetate of zinc has been prescribed internally, upon theoretical grounds, and without advantage. The carbonate of lead has been applied, mixed with linseed oil, as a paint; but if any lesion of the skin exists, it is apt to be poisonous. Flexile collodion has also been used to protect and constringe the affected skin, but is more painful than useful in all cases of erysipelas that really call for active treatment. Solutions of gutta percha and also of salicylate of sodium have been employed for the same purpose, and with analogous results. Mechanical compression of the affected part has been made by bandages, especially in surgical erysipelas of the limbs. Velpeau, who was one of the first to make use of it, limited its application to cases in which the inflammation did not extend deeply beneath the skin, and perhaps, like the astringents already noticed, it tended to retard or limit the inflammation. But the impossibility of anticipating the future course of any such affection, and the great danger of the parts swelling beneath their bandages so as to produce, as actually happened in several cases, not only excessive pain, but ulceration and gangrene, suffice to condemn this method which, in reality, was the product of crude theory and not of clinical experience.

Another method of local treatment consists in the application of *stimulants* to the inflamed part. One of the first used of these was a *blister*, the extent of which was limited only by that of the erysipelas. Cases are on record in which it was made to envelop an entire limb; and although, as usually happens to medicinal agents, its novelty brought it some applause, and not a little false credit, its condemnation was not slow to follow, for the demon-

[1] Neftel, Medical Record, vol. iv. p. 79.

stration of its good and evil results was not difficult. Subsequently, blisters were applied around limbs affected with erysipelas, not upon the inflamed portion, but upon the sound skin at a little distance from the latter, and were believed to prevent the extension of the disease in that direction; but experience has shown that this belief was delusive, and that erysipelas pays no respect to any such barriers in its path. Almost identical with fly-blisters in its mode of operation in this disease is a strong solution of *nitrate of silver*, for which a claim was long ago made, and more recently renewed by its proposer, Dr. Higginbottom, that it absolutely arrested the progress of the disease. The total loss of faith in this vaunted remedy, which was not only painful but inefficacious, is another fact among the many which prove that erysipelas is as little to be cured as smallpox by remedies applied to the skin. Of agents belonging to this class, *iodine* is one of the best. It has, of course, an array of "cures" in its favor; but it is certainly a valuable palliative of the pain and swelling in some cases of erysipelas, especially of the face. The compound solution, or the compound tincture, should be painted on the inflamed part.

It is unnecessary to discuss the value of the *actual cautery*, or the *moxa*, which have been vaunted by certain surgeons in this disease; they are as cruel as they are useless. As a substitutive and protective agent, the liniment of *turpentine*, or *Kentish's ointment*, is a very convenient palliative of the local symptoms in cases of superficial erysipelas, and has long been used for that purpose. More recently (1869), Luecke[1] conceived that it had a specific power of destroying the hypothetical virus of erysipelas. Another medicine whose mode of action was conceived to be similar, is *hyposulphite of sodium*, and its curative powers were attested by several physicians and surgeons of established reputation. But as the success of the medicine was said to be just as great whether it was employed internally or topically, we may fairly conclude that its virtues were more apparent than real, an inference which is quite confirmed by the complete neglect into which it has fallen since its first introduction, about 1860. A like estimate which has been made of *iodide of calcium*, probably calls for a similar criticism. Among the topical applications used in this disease, *camphor* may be mentioned, which is anodyne, and when used in alcoholic solution and allowed to evaporate, is also somewhat cooling. At one time *mercurial ointment* was held by some authorities to be almost certain to arrest the inflammation and extension of erysipelas; but such effects were soon found to be uncertain, if not unreal, while the frequent occurrence of salivation after the mercurial inunction led to its general disuse. That it cures cases of the disease which would not get well spontaneously, cannot be admitted. Finally, it may be mentioned that *bromine* has been used in watery solution, as a lotion. As far as it is useful in superficial erysipelas, it may be supposed to act as a local stimulant and anodyne. In phlegmonous erysipelas, when an opening exists, and especially when sloughing of the cellular tissue takes place, a solution of bromine may be used as a stimulant and disinfectant.

Surgical Treatment.—The surgical treatment proper of erysipelas, relates mainly to the management of those cases of the phlegmonous form of the disease in which openings must be made through the skin, to give exit to dead connective tissue and the liquid products of inflammation; but it also relates to that of the wound which is the starting-point of the attack. But often the inflammation forms bullæ, or abscesses, which are of limited extent, and do not require any other treatment than would be appropriate in the absence of erysipelas, viz., the evacuation of the blebs and abscesses, and their

[1] Bulletin de Thérapeutique, t. lxxvi. p. 422.

dressing with wet compresses or poultices, or with dry astringent powders, or with salves. The same applications are suitable when superficial sloughs occur. As such sloughs often form upon parts the integument of which is delicate, as upon the eyelids, the ears, and the genital organs, if this accident appears to be due to the tension of the part more than to the delicacy of the skin, it is generally prudent to diminish the pressure by punctures or incisions that will give issue to the subjacent liquid. When phlegmonous inflammation of the connective tissue takes place, it is the usual practice, if not always necessary, to make openings through which the products of inflammation can escape. This may sometimes be effected by *punctures*, or more thoroughly by free *incisions* (Copland Hutchison), at the most convenient, depending point of the swelling; but not unless the tension of the part, its painfulness, the tendency of the suppuration to advance, or the threatening of gangrene, furnishes the indication for interference.

Punctures were highly recommended more than half a century ago by Dobson, who employed them in all cases, in number from ten to fifty, and varying in depth from two to four-tenths of an inch, repeating them from two to four times in the twenty-four hours, and on the scalp, face, trunk, or extremities, as occasion required. He contended that not only were the integuments better preserved by making several small openings than by one large incision, but that the effused matter was quite as well evacuated.[1] It may be objected to this method that it involves a very unnecessary suffering in all forms of erysipelas, except the phlegmonous, since they spontaneously tend to recovery; and at the time of its original proposal, it was said not to be adapted to the phlegmonous form. It was, however, a mild procedure in comparison with that of Lawrence, for which it was proposed as a substitute, and which consisted in "making incisions through the inflamed skin and the subjacent adipose and cellular textures," which were sometimes of appalling length. In one case, it is said, "an incision was made from the ham to the heel," and in another, involving the forearm, the cuts "extended nearly the length of the limb." The method by punctures, and that by short incisions, seem to be quite sufficient for all the exigencies of this disease. The former is said to be adapted to its early stages; but, as already suggested, the necessity of the procedure is so far from apparent, that it would seem to be called for only in exceptional circumstances. In the brawny stage of the inflammation, it is recommended that "incisions from one to two inches long, and two or three inches apart, should be made over the inflamed surface, in the general direction of the subjacent muscular fibres" (Ashhurst), and on alternate lines, thus | | |, "the greatest relief from tension being thus obtained with the least destruction of tissue." "At a later stage, when brawniness has given place to bogginess, showing that sloughing of the subcutaneous tissues has already occurred, free and deep incisions, three or four inches long, may be required, in order to prevent gangrene of the skin, and to afford exit for sloughs, the separation of which may be hastened by the forceps and scissors. Warm fomentations should be constantly applied, and antiseptics may be freely used, not only in the dressings, but injected among the tissues by syringing. When the suppuration is very profuse, the fomentation may be omitted, the part being simply covered with lint and charpie, tow, oakum, or carded cotton, and supported by the gentle pressure of a bandage" (Ashhurst). When there is, as is most apt to be the case in traumatic erysipelas, even less tendency to circumscription of the disease,

[1] Medico-Chirurgical Review, August, 1828, p. 383.

and from the first the part is soft as well as greatly swollen, and the type of the attack typhoidal, such incisions as have been described are imperatively necessary to lessen the danger of gangrene of the skin, and to furnish an outlet for the products of decomposition. "In the scalp, crucial incisions are the most effective, while in the scrotum a single free incision on either side of the raphe will usually be all that is necesssary." When the eyelids are much swollen, it is prudent to incise them parallel to their folds, to prevent purulent collections. If the eyeball becomes very prominent, and there is reason to believe that pus is infiltrated behind it, a deep incision of the soft parts that line the floor of the orbit is called for, and a blunt probe or director should be introduced to the supposed seat of the pus, to guide the blade of a lancet or bistoury, held flatwise.

Besides the use of *carbolic acid* as a dressing in the proper surgical cases above noticed, it has been employed in different manners. Thus it is stated by Zuelzer[1] that Kaczorowski applied to the inflamed surface a mixture of one part of carbolic acid and ten of oil of turpentine, which, after temporarily irritating the skin, subdued its inflammation in a marked degree; that Wilde injected subcutaneously into the inflamed part a solution of sulpho-carbolate of sodium (1 : 12); and that Hüter employed a three per cent. solution of carbolic acid in the same manner. Tillmanns's experiments led him to the conclusion that a carbolic acid solution (2 to 4 per cent.) rendered a previously active erysipelatous inoculating liquid quite inoperative,[2] and he has more recently recommended the hypodermic injection of a similar solution around the limits of the affected skin in the earliest stages of the inflammation. This mode of treatment is said to cause no pain, and to render the skin pale and wrinkled.[3] Tassi claims to have cured four cases of erysipelas by means of a saturated solution of the acid employed in the same manner.[4] Rothe attributes to the following lotion a mitigation of the inflammation in duration and severity: ℞. Acid. carbolic. gr. xv; alcohol, ♏xv; ol. terebinthinæ, f℥ss; tr. iodinii, ♏xv; glycerinæ, f℥iss. M. With this the part should be bathed every two hours, and kept covered with cotton-wool. Dr. S. J. Radcliffe has reported the case of a very old and feeble woman, in whom erysipelas, beginning at a bunion on the foot, extended to the whole of the lower extremity, producing enormous swelling, and attacked the buttock where it occasioned an eschar. After the total failure of local protectives and of the internal use of iron and quinia, he applied a solution (1 : 16) of carbolic acid in olive oil, three times a day, covering the part, also, with cotton-wool. Relief was obtained almost immediately, the local phenomena rapidly declined, and the patient recovered.[5] Dr. A. G. Miller, of Edinburgh, while inclined to regard as useful the internal employment of sulpho-carbolate of sodium, and that of the carbolates of sodium and quinia, refers to their irritant effects, and especially those of the latter preparations, upon the stomach and bladder.[6]

The internal medication of erysipelas in ancient times consisted, as we have seen, chiefly in the use of *purgatives*, which were believed to be cholagogue, and which appeared to be indicated by the gastric derangement which is the usual accompaniment of the first stage of febrile affections in warm climates. In recent times, *emetics* have been more generally employed for a similar purpose, and perhaps, by the shock which they give the system, to break up

[1] Ziemssen, loc. cit. [2] Edinburgh Medical Journal, vol. xxv. p. 667.
[3] Philadelphia Medical Times, January, 1881, p. 201.
[4] Bulletin de Thérapeutique, t. c. p. 239.
[5] Philadelphia Medical Times, vol. xi. p. 455.
[6] Edinburgh Medical Journal, vol. xxv. p. 1095.

"the chain of morbid associations," to use the figurative but not unmeaning phrase of another epoch. However this may be, the frequent occurrence of spontaneous vomiting was supposed to indicate a biliary derangement, and "a saburral condition" of the stomach, and this belief was confirmed by the accompanying thick coating upon the tongue. But now it is certain that vomiting is a frequent precursor of febrile attacks of very diverse nature, and that the degree and nature of the tongue's coating is immediately related to the general state of the system, and not at all to that of the stomach. Although the reasons given for an emetic treatment of erysipelas may have been groundless, the method itself may have been good, by as much as facts are generally better than opinions, and practice than theory. It may very well be that an emetic or an emeto-cathartic given in the forming stage of this as well as of many other febrile diseases, will tend to mitigate its severity and modify its course, partly by cleansing the alimentary canal of its putrescible contents, and partly by quickening all the eliminative secretions, and very possibly by expelling in this manner a portion of the morbid poison contained in the blood. It is a treatment which may be eligible without being elegant, and that it is the former, our experience, especially in hospitals, does not permit us to doubt. The most appropriate emetic is ipecacuanha, the most unsuitable, as a rule, is tartar emetic; or, if the latter be used, it should be prescribed in small doses dissolved in a weak solution of Epsom salt or some analogous saline. The emetic treatment, it need hardly be added, is not so well adapted to surgical as it is to medical erysipelas.

The use of *alcoholic stimulants*, in ordinary cases of the disease, is not only unnecessary but injurious, for they increase the fever, lessen the appetite for food, and impair the digestive function. It was part of a system of stimulation which Dr. Todd, of London, brought into vogue about 1860, to administer in this disease, at stated times and in small doses, so as not to excite nausea and intolerance, beef-tea and brandy. He even went so far as to say, "If I were restricted to one remedy in this disease, I should assuredly choose brandy."[1] And he repeated and elaborated this idea in his clinical lectures published four years later. Considering that he had to do with neither surgical (traumatic) nor puerperal erysipelas, it is certain that he went far beyond either his contemporaries or his successors, in his recommendation. Nothing can be more certain than that erysipelas, as such, stands in no need of alcoholic treatment; but that the typhoid forms and states of the disease may and generally do call for it, as the same conditions do in all other febrile affections, is unquestionable. And not only for alcohol but for other stimulants, cardiac and nervous, of which *oil of turpentine* is by many ranked highest, as it is also in whatever form of fever a tendency to the typhoid state is most marked; and next to it, or even higher but for its more transient operation, *carbonate of ammonium* may be placed.

Not many years ago, the prevalent theory of erysipelas attributed its phenomena directly to the extravasation of the white corpuscles of the blood, and, as at that time *quinia* became endowed with a specific control over this migration, it was looked upon as the natural antidote of erysipelas. But as the theory could not be made to embrace all of the cases in which the utility of quinia had been demonstrated, another virtue was assigned to it, viz., that of destroying disease-germs; and, finally, this being found an inadequate explanation, the antipyretic virtues of quinia were invoked to account for its power in curing erysipelas. It was omitted, however, to show that in any true and real sense quinia did cure, *i. e.*, arrest, this disease. It is claimed that the use of large doses of quinia in erysipelas was instituted, in this

[1] Medical Times and Gazette, January, 1855, p. 29.

country at least, by Surgeon Satterlee, U. S. A., as long ago as the Florida Indian war, in 1835. In 1836, Latham[1] claimed that in certain cases the patients must have died without quinia, and that it "cured them outright, without the fulfilment of any intermediate purpose whatever;" and he recalled the fact that at the beginning of the present century bark was regarded by all experienced physicians as a specific for erysipelas. Indeed it was prescribed by Heberden, Hoffman, Fordyce, Pearson, Cooper, and many others, to control a tendency toward the typhoid state so characteristic of this disease. In 1857, Coale prescribed ten grain doses of quinia in pharyngeal erysipelas.[2] More recently, quinia has been employed for quite a different purpose, viz., in such doses as to produce a sedative impression. In 1874, Dr. F. Satterlee recommended the administration, in the forming stage of the attack, of sulphate of quinia in doses of twenty-five or thirty grains, but if the disease was fully developed, he directed a similar dose every night for three successive times. He claimed that in some cases a single one of the doses mentioned proved sufficient to abort the attack, while in other instances the temperature and pulse fell greatly, and the general symptoms either disappeared or improved, from twenty-four to forty-eight hours sufficing to abort the disease.[3] Binz and Liebermeister have also used this method with like results. It may be added to these statements, without attributing to it great weight, that, according to Rombla, hydrobromate of quinia, employed hypodermically, caused a rapid subsidence of the symptoms in a case of typhoid erysipelas.[4] It will be observed that equal success is claimed for quinia, whether it is given in small or tonic doses, or in massive, sedative, or so-called antipyretic doses. Theory apart, it must be believed that the former are most appropriate in the epidemic and typhoid forms of the disease, and the latter in the more sthenic cases, of which erysipelas of the face, as it ordinarily occurs, may be taken as the type.

Tincture of chloride of iron was, at one time, regarded as almost a specific, at least in the idiopathic forms of erysipelas. In 1851, Mr. G. H. Bell, of Edinburgh, declared that for twenty-five years he had made use of it without having in a single instance failed of success. In mild cases he prescribed fifteen drops, and in severe cases twenty-five drops, of the medicine every two hours, night and day, however high the fever and delirium, until the disease was completely removed. These conclusions were confirmed by C. Bell and others. In 1852, Begbie related several cases in which the exhibition of the medicine was quickly followed by a remission of all the symptoms.[5] Pirrie stated, that under its use, "the febrile condition seemed to be relieved, the frequency of the pulse reduced, the powers of the system generally to be upheld, and the stomach and bowels in no way irritated. Headache and sensorial disturbance diminished under its use." He prescribed 15 to 20 drops every two or three hours, until convalescence was fairly established.[6] In France it was used soon afterwards by Aran, Mathey, and others. According to Mathey, by the third day after the medicine was commenced, often by the second, or even by the first day, the progress of the disease was checked. He, however, prescribed not more than thirty drops a day; but Aran increased the dose to twice or three times as much, or even more than this, and obtained equally satisfactory results. He conceived that certain cases were not benefited by this treatment, especially those occurring in young

[1] Op. cit., p. 461.
[2] Boston Medical and Surgical Journal, February, 1857, p. 63.
[3] New York Medical Journal, vol. xx. p. 579.
[4] Compendium de Thérapeutique, 1880, p. 83.
[5] Monthly Journal of Medical Science, September, 1852, p. 243.
[6] Edinburgh Medical Journal, July, 1861.

and healthy persons of a sanguine temperament, and that it was most efficient when the patients were of a delicate, feeble, lymphatic constitution, or had been exhausted by previous disease, when the local inflammation was œdematous rather than phlegmonous, the pulse soft rather than tense, and the temperature not very high. It appeared to be most useful in the milder and more superficial forms of traumatic erysipelas, in the chronic and wandering forms, in a word, in all that involved debility of the system. It would seem, also, to have been successfully used as a prophylactic for persons about to be operated upon in surgical wards where erysipelas prevailed.[1]

As late as 1880, the utility of tincture of chloride of iron in this disease was still recognized in Edinburgh, for it is stated by Miller that in the Royal Infirmary in that city the ordinary treatment of erysipelas consisted of a purge, milk diet, and the iron tincture, with a dressing of flour and cotton-wadding. Its effect on the milder cases was manifested in a few hours invariably. With these statements the experience of the writer substantially agrees, and while the measure of the medicine's utility is not always the same, it appears to him none the less prompt and decided, although most unequivocally so in the less sthenic forms of the disease. The impression he has received from his experience is that this preparation has a double mode of action; that it acts by constringing the bloodvessels, and thereby limiting the inflammatory process, and that while it tends to maintain the normal constitution of the blood, it also counteracts the noxious operation of the poison in the system.

It is proper, however, to state that a less favorable judgment has been pronounced by some clinical observers. Long ago, Todd, prepossessed, no doubt, in favor of his own stimulant method, considered that the iron might be useful in otherwise benign cases, partly and chiefly because it excluded depressing treatment. "But," he added, "I would as soon think of trusting to it in the treatment of grave cases, as I would to the billionth of a grain of aconite, or of arnica, or sulphur, or any other homœopathic absurdity;"[2] but five years later he softened this contemptuous judgment by the advice not to trust to the medicine alone, "but merely to use it as an adjunct to the stimulant regimen."[3] Neftel was not very happy in declaring that the medicine "ought to be entirely discarded from the treatment of erysipelas, for, like all the preparations of iron it increases the temperature, and is therefore injurious in febrile diseases."[4] The question is not whether iron raises the temperature, but whether this preparation of it tends to cure erysipelas. Estlander pronounced it to be of no real utility;[5] and Dr. R. J. Lee concluded that cases treated with it were of longer duration than usual.[6] But the weight of testimony upon the subject is altogether against these objectors.

It would be easy to enumerate many other medicines than the few which have been mentioned, and which have been set forth as possessing a really modifying and curative influence in this disease, but as a type of them may be given the following conclusion respecting one of them, by a writer upon the subject: "It is difficult to decide which is the best treatment, but experience seems to point to bicarbonate of soda, largely diluted with water, to be drunk warm."[7] Such conclusions indicate how great is the incompetency of some observers to judge of the operation of medicines.

[1] Bulletin de Thérapeutique, t. liii. p. 12.
[2] Medical Times and Gazette, July, 1855, p. 30.
[3] Clinical Lectures, 1860, p. 216.
[4] Medical Record, vol. iv. p. 78.
[5] Medical Times and Gazette, December, 1871, p. 716.
[6] Practitioner, vol. viii. p. 158.
[7] Braithwaite's Retrospect, Quarterly Epitome, 1880, p. 171.

In erysipelas of *infants at birth* no treatment is of much avail, but it necessarily must consist mainly of topical agents, such as have been enumerated for the disease as it occurs at a later age. Of these, oxide of zinc and mercurial ointments are most generally recommended. When erysipelas affects persons at the opposite extremity of life, the only modification of the ordinary treatment should consist in the free but judicious administration of alcoholic stimulants, and of the preparations of bark in tonic and stimulant doses. When the disease commences in the *fauces*, or extends into the *larynx*, these parts should be treated with astringents (nitrate of silver, chloride or sulphate of iron), which may be applied by means of a swab or brush, or, still better, by means of the steam atomizer, which is equally appropriate when the inflammation invades the *bronchia.* If the swelling of the mucous membrane of the larynx interferes with respiration, it should be scarified, and, if this procedure fail to give relief, the operation of tracheotomy remains as a last resource. It is possible that a large blister on the chest might be of service, but the evidence of its virtues is not conclusive.

It is unnecessary in this article to discuss in detail the treatment of *epidemic erysipelas*, or even of those typhoid states of the disease in its sporadic form which are occasionally met with. As in all similar cases, the treatment of the local affection must be subordinated to the type of the attack, that is to say to the treatment of the typhoid state. In carrying out this idea, the practitioner must not be misled by the delirium, etc., into believing that a *meningitis* exists, for no lesions representing that disease are ever found after death. The most efficient remedies are alcohol and opium, or, for the former, coffee may be substituted, and quinia in small and repeated doses should be given, while stimulating food is not omitted. As in other typhoid affections, serpentaria, ammonia, camphor, musk, etc., may be useful. In this form of the disease, good nursing is of primary importance, and includes not only the hygienic measures that have been pointed out, but the watchful and judicious administration of stimulants, tonics, and food, as they may be required by the varying condition of the patient.

PYÆMIA AND ALLIED CONDITIONS.

BY

FRANCIS DELAFIELD, M.D.,

ADJUNCT PROFESSOR OF PATHOLOGY AND PRACTICAL MEDICINE IN THE COLLEGE OF PHYSICIANS AND SURGEONS, MEDICAL DEPARTMENT OF COLUMBIA COLLEGE, NEW YORK.

Nomenclature.

It has long been known that a certain number of patients, who have received wounds by accident, or by the hands of the surgeon, may suffer from general constitutional symptoms of greater or less severity. To designate the condition of these patients, the terms pyæmia, septicæmia, septico-pyæmia, ichorrhæmia, inflammatory fever, surgical fever, traumatic fever, suppurative fever, purulent infection, etc., have been used. These terms, however, are used in different ways by different authors. At first the tendency was to group all these conditions together. Since 1848, however, pyæmia and septicæmia have been distinguished as different conditions. At the present time many different views prevail.

Billroth defines septicæmia to be "a constitutional, generally acute disease, which is due to the absorption of various putrid substances into the blood, and," he adds, "it is thought that these act as ferments in the blood, and spoil it so that it cannot fulfil its physiological functions." Pyæmia is "a disease which we suppose to be due to the absorption of pus or its constituents into the blood." Hueter says "septicæmic fever is produced by the entrance of products of putrefaction into the blood. It is possible that the products of putrefaction are of different kinds, and that consequently there are different varieties of septicæmia." He defines pyæmia as follows: "Pyæmic fevers are developed by the introduction into the blood of the components of pus, either the serum or the pus globules. The pus may enter directly into the blood-vessels or lymphatics, or it may first form parts of thrombi in the veins, and then enter the circulation, carried in the fragments detached from these thrombi." He distinguishes simple pyæmia from metastatic pyæmia, and he also admits of a combination of pyæmia and septicæmia, which he calls septico-pyæmia. Burdon Sanderson says: "What I mean by septicæmia is a constitutional disorder of limited duration, produced by the entrance into the blood stream of a certain quantity of septic material. It must, therefore, be regarded, not so much as a disease as a complication, differing from pyæmia, not only in the fact that it has no necessary connection with any local process, either primary or secondary, but also in the important particular that it has no development. Pyæmia is a malignant process, which goes on and on to its fatal end; but in the case of septicæmia, inasmuch as the poison which produces it has no tendency to multiply in the organism, there is no reason why the morbid process should not come to an end of itself, unless either the original dose is fatal, or a second infection takes place from the

same or another source." Mr. Savory, speaking in the debate on pyæmia at the Clinical Society of London in 1874, classes septicæmia and pyæmia together as but different degrees of effect of the same poison. The London Royal College of Physicians defines pyæmia to be "a febrile affection resulting in the formation of abscesses in the viscera and other parts." Ordinary usage, at the present day, applies the term pyæmia to those cases in which infarctions, abscesses, and local inflammations are present; while the term septicæmia is employed to designate cases in which similar clinical symptoms exist, but in which no lesions are found.

But, as Koch says, the names pyæmia and septicæmia no longer express what was originally meant by them. For pyæmia does not arise, as was formerly supposed, from the entrance of pus into the bloodvessels, nor is septicæmia a putrefaction of the living blood. These have only remained in use as general names for a number of symptoms, which most probably belong to a series of different diseases. In this article the word pyæmia will be used as a general term to designate the entire group of cases.

Nature of Pyæmia.

There are three theories which have been held as to the nature of pyæmia:—

I. That pus is absorbed, circulates in the blood, and acts as a poison;

II. That a chemical poison is evolved from pus and the other matters which are found in wounds, and that the system is poisoned by this;

III. That microscopic organisms are introduced into and developed in the wound, find their way into the blood and tissues, and there multiply.

I. The Theory of Pus Absorption.—The idea that pus can be absorbed and act as a blood poison, is a very old one, dating from the times of Ambroise Paré (1561) and Boerhaave (1720). Hunter, in 1784, modified the prevailing views by declaring that the pus was derived from the interior of inflamed veins, and found its way from thence into the circulating blood. The idea that the symptoms and lesions of pyæmia were due to the presence of pus in the blood, whether absorbed from wounds or from inflamed veins, continued to prevail, based partly upon clinical observation, partly upon the results of injections of pus into the veins of animals, until there appeared, in 1846 and in subsequent years, the studies of Virchow concerning *thrombosis* and *embolism*. He showed that the changes in the veins which had been regarded as due to phlebitis, were caused by the coagulation of the blood, and by subsequent degenerative changes in the thrombi thus formed; that the infarctions and abscesses seen in the viscera were due to emboli which had become detached from the softened thrombi; that, as the white blood globules and pus globules were identical in appearance, they could not be distinguished; and that it was improbable that pus globules made their way into the blood. These researches afforded a mechanical explanation of some of the lesions of pyæmia. But there was still a tendency to ascribe to the absorption of laudable pus a certain number of the lesions and symptoms. Sédillot, Weber, Billroth, and others, have held that laudable, fresh pus, was capable of being absorbed, and of producing a febrile movement. This opinion has, indeed, been controverted, but the doctrine of the absorption of laudable pus has hardly yet disappeared from pathology.

II. The Chemical Theory.—Gaspard (1822), one of the earliest investigators of septicæmia, suggested that the poison might be one of the chemical products of putrefaction. This opinion was sustained during subsequent

years by other observers. The most thorough studies of the subject, however, from this point of view, are those of Panum (1855 and 1874). His studies were careful and systematic, and were carried on during a number of years. His conclusions are essentially as follows: "It is demonstrated that there is in putrefying fluids a specific, chemical substance, soluble in water. This substance, if introduced into the blood, produces the peculiar symptoms which belong to what is usually called putrid or septic infection. This substance possesses such infectious properties after being completely freed from all microscopic organisms." Attempts to isolate this infectious substance and find a definite chemical composition for it, have not been successful. Hiller (1876) also went over the ground very thoroughly, and arrived at the conclusion that there were two putrid poisons: A chemical poison, producing symptoms in proportion to its dose; and a septic ferment of great malignity, a malignity increased by successive inoculations. Besides these views of a chemical, putrid poison, it must not be forgotten that the introduction of a variety of substances into the circulation can produce fever. Blood, solutions of sulphate of ammonium, even distilled water, can act in this way. It must also be remembered that in simple fractures, where no air or germs contained in the air can approach the wound, there may be fever. In such cases it seems probable that the absorption of the tissues destroyed by the contusion may be the efficient cause.

III. The Germ Theory.—This theory is founded on Pasteur's studies concerning putrefaction and fermentation. He has demonstrated, to almost universal satisfaction, that putrefaction and fermentation are due to the presence and growth of certain minute organisms; that unless these organisms are present, fermentation and putrefaction do not take place; that these organisms are in suspension in the air, and that it is for this reason that the access of air induces putrefaction. From these facts came the probability that the different infectious diseases might be due to analogous processes; to the introduction of microscopic organisms into the body, and to their multiplication there. Septicæmia and pyæmia have been especially studied from this point of view. Notwithstanding all the work that has been done, however, we are still far from positive results. Investigations have been carried on in two directions: (1) examinations of the blood and tissues in persons who have died of pyæmia and septicæmia; and (2) the production and study of similar lesions in animals.

(1) *The Examination of the Blood and Tissues in Persons who have Died of Pyæmia and Septicæmia.*—This study is rendered singularly difficult by the minute size of the microscopic organisms, and all attempts to distinguish these bodies by means of staining or of chemical reagents have so far proved unsatisfactory. They are found of two principal shapes; little rods of various sizes, which may be single or joined in chains; and little globules which are collected in masses, or joined to form chains or dumb-bells, or scattered singly. The generic name for both is *bacteria*, but it has become customary to call the rods bacteria, and the little round bodies *micrococci*, although other names have also been given to them. The larger rods and the clumps of micrococci can usually be made out, but the smallest rods and the scattered micrococci are always uncertain objects. It is also still undecided whether the micrococci and bacteria are the same organism in different stages of development; whether there are a variety of these organisms, one for each infectious disease; whether any of them are altogether harmless. Observations differ also as to whether the rods or the micrococci, or either indifferently, are the active agents.

Birch-Hirschfeld, examining the fluids from a number of wounds, found

that the pus from healthy wounds sometimes contained rod bacteria, sometimes no organisms; but that when micrococci were present, the wounds were uniformly unhealthy. In the blood of pyæmic patients, he found sometimes nothing, sometimes micrococci in the plasma and in the white blood-globules. He also found that pus from pyæmic patients was more infectious than putrefying fluids, when injected in animals, and that such pus was less infectious after it had begun to putrefy. He believes that the micrococci rather than the rod bacteria produce pyæmia. On the other hand, Ranke has found micrococci regularly present in wounds treated antiseptically. Cheyne found that no rod bacteria were present in the discharges from wounds treated antiseptically, but that micrococci were often present. He regards the presence of bacteria as causing pyæmia, while micrococci, he believes, are harmless.

The committee of the London Pathological Society found that organisms were sometimes present in the blood, sometimes absent. Rods were found most constantly, but besides these, ovoid bodies measuring from 3 μ to 8 μ [micro-millimetre $= \frac{1}{1000}$ millimetre]; other larger granules, sometimes in clumps; and dumb-bells. In the organs and tissues after death, the committee found, in a large number of cases, micrococci; especially in the thyroid gland, heart, lungs, liver, kidneys, suprarenal capsules, spleen, lymphatic glands, and blood clot. They were nearly always in bloodvessels and usually in capillaries. Bacteria were only found in two cases, both somewhat doubtful. Many other observers have also found micrococci in the tissues.

The general results of the examinations of the human subject are that, in the wound, both rods and micrococci are found, but that it is doubtful whether one or the other, or both, are the harmful agents; in the blood, both rods and micrococci are sometimes found, rods most frequently; in the tissues, micrococci are found frequently, rods but seldom.

(2) *The Experiments on Animals* have consisted chiefly in inoculating animals with pus from pyæmic patients; with putrefying fluids of different kinds, especially blood; and with blood from other animals.

The inoculation of *pus* from the wounds of pyæmic patients is usually fatal to animals; sometimes without any lesion, sometimes with metastatic inflammations (Birch-Hirschfeld).

The inoculation of *putrefying blood or other fluids* acts in three ways. Large doses destroy the life of the animal after a short time. Small doses produce no symptoms, or transitory ones; or after some hours the animal becomes ill, emaciates, gradually loses strength, and dies. The putrefying fluids injected, always contained bacteria, and most observers hold that if the bacteria are removed, the remaining fluid is harmless. But Panum has shown that the fluid may be poisonous after the removal of the bacteria; and Hiller has shown that the bacteria, when isolated from the putrid fluid, may be harmless. Davaine has shown that, in septicæmic animals inoculated successively one from the other, the blood becomes constantly a more virulent poison. Burdon Sanderson has shown that, if a peritonitis be first artificially produced by some chemical irritant, the fluid from such a peritonitis will by successive inoculation become more and more virulent, and will contain bacteria.

There has been considerable diversity of opinion as to the constancy of the presence of organisms in the blood of animals thus inoculated. Koch, in his experiments on mice, found in the blood of those killed by large injections of putrid blood, a few rods of different sizes, and micrococci; but if the animals were inoculated with a very little septic fluid and developed septic symptoms, then only the small rods were present in large numbers. Pasteur has endeavored to isolate the organisms peculiar to pyæmia by successive culti-

vations. He has arrived at the conclusions that there is a special rod-shaped form of bacteria, peculiar to pyæmia; that this organism does not grow in contact with the air, but is killed by it (*anaérobie*); that micrococci are developed from these rods, which are not affected by the air, and which can under favorable conditions grow into rods; that there is another form of rod-bacteria which produces local suppuration.

There seems good reason to believe, from all these different experiments, that putrefying fluids, when injected beneath the skin or into the veins of animals, produce serious symptoms, or death. These putrefying fluids invariably contain bacteria. If the bacteria are removed by filtration, boiling, etc., the fluid is still poisonous (Panum). If the bacteria removed by filtration are injected, they are also poisonous; but if these bacteria are washed repeatedly, they may be innocuous (Hiller). On the other hand, successive cultivations of a particular kind of bacteria, in indifferent fluids, produces an organism which is constantly poisonous (Pasteur).

These putrefying fluids seem to act in two ways: (1) as a direct and rapid poison; (2) in small doses as a slower poison. In the animals killed by large doses, few or no bacteria are found in the blood, nor is their fresh blood poisonous to other animals. In the animals killed slowly, by small doses, bacteria are found in the blood, and the fresh blood is poisonous to other animals. It is still uncertain whether the symptoms and lesions produced in animals by such injections of putrefying fluids, are identical with the symptoms and lesions of pyæmia in man.

Symptoms and Lesions of Pyæmia.

It is impossible to describe the symptoms and lesions of pyæmia, as we can those of a definite disease. The best that can be done is to enumerate the different conditions which are commonly spoken of under the name of pyæmia, and to describe the symptoms and lesions which belong to each condition.

I. There are a certain number of cases of wounds and of injuries, which are characterized by the presence of a febrile movement, without any other symptoms. The wound is healthy, the patient's general condition is good, the febrile movement is of moderate intensity, lasts a few days, then disappears, and the patient goes on to recovery. This symptom occurs in cases of wounds which are left open, in a certain number of cases in which the wounds are treated antiseptically, and in simple fractures, especially fractures of the thigh (Volkmann). In these cases, there seems to be no infection from without; no development of any organism; no formation of a chemical poison. It seems probable that the febrile movement is due to the absorption of portions of tissue which are dead, but not putrefying. In such wounds and fractures, the injury is often sufficient to destroy the vitality of some portions of tissue. These portions do not putrefy, but undergo necrobiotic changes. The absorption of such dead tissues in certain susceptible persons may be capable of producing a febrile movement.

II. There are cases in which in some part of the body a portion of tissue is not only dead, but undergoing putrefaction. While this process of putrefaction is going on, the patient suffers from rigors, a febrile movement, disturbance of the stomach and great prostration, and may even die. But if the putrefactive process is arrested in time, all these symptoms at once disappear, and the patient recovers. The most marked examples of such a condition

are seen after childbirth. A woman, after a natural labor, is doing perfectly well, until on the fourth day she is seized with rigors, a febrile movement, and vomiting. The temperature runs up to 104°, there is great prostration, the woman looks very ill. She remains in this condition for 48 hours; then, after repeated syringing, a small piece of putrid membrane is discharged from the uterus. Within half an hour the temperature has fallen to the normal, and the patient has no other bad symptoms. The cases may be even more serious than this; J. Matthews Duncan reports the following:—

A. E. was delivered naturally of her second child on June 8. Flooding occurred after the birth of the child, and slight loss of blood continued for seven days. Then the lochia became fetid. On the eighth day, she had rigors, which were repeated daily. She was brought into the hospital on the tenth day, and was delirious that night. On the eleventh day, she complained of no pain, was pale, sick, frequently vomiting, with diarrhœa, the uterus tender, breath sweet, respiration 44, pulse 146, temperature 104°, copious flow of stinking lochia. A piece of placenta was removed from the vagina. Under the influence of chloroform the hand was introduced into the uterus, and adherent placental masses were removed. The whole genital tract was then washed out with a solution of carbolic acid. That night the delirium ceased; the pulse was 100, the temperature 101°. After this, the recovery was uninterrupted.

Similar symptoms are seen in some persons who have received wounds.

A man, 19 years old, was shot in the popliteal space. On the same day the bullet was extracted, and the wound dressed antiseptically. The wound discharged so freely a sero-sanguineous and sero-purulent fluid, that the antiseptic dressings were renewed on the 1st, 2d, 4th, 5th, and 6th days after the injury. On the 2d day, the temperature was 100° F. in the evening. On the 4th day, the temperature was 101° in the evening; on the 6th day, 102° throughout the day. But, except for the febrile movement, the patient was feeling well. On the 7th day, the dressing was renewed; and it was found that the edges of the wound were dark-colored and sloughing; temperature 100°–102°. On the 8th day, the dressing was again renewed; the wound was unhealthy and smelt badly, temperature 100°; general condition of patient continued good. On the 13th day, there was so much bleeding that it was necessary to ligate the popliteal artery; this was done antiseptically, temperature 98°–102°. On the 14th and 15th days, the dressings were changed; there was a good deal of bad smelling discharge from the wound, temperature 100°–101°. On the 16th day, the wound was foul and sloughing, temperature 101°–103°. From the 17th to the 25th days, the patient had repeated rigors, followed by sweating, temperature 98°–102°, wound continued unhealthy; patient lost flesh and strength; there was apparently a thrombus in one of the superficial veins of the leg. After the 25th day, the condition of the wound improved, the temperature fell; the rigors and sweating gradually ceased. By the 46th day, the wound had healed, and the patient was well.

In this case, notwithstanding antiseptic dressings, the wound became unhealthy and contained putrefying tissue and fluids. While the wound remained in this condition, there was a febrile movement of moderate intensity, and a gradual loss of flesh and strength; the rigors and sweating may have been due to the venous thrombosis. When the wound became healthy, and the putrefying substances had disappeared, the symptoms ceased and the patient recovered.

If the amount of putrefying tissue is sufficiently large, and if it is not removed, the symptoms of poisoning continue, and the patient dies.

A man, 38 years old, who had suffered for several years from disease of the knee, submitted to resection of that joint. On the day after the operation, there was some fever. The wound was not dressed antiseptically, a thin sanious fluid exuded from it. There was no attempt at repair until the 7th day, when the superficial portions of the wound commenced to granulate. The fever continued, the patient emaciated, and on

the 9th day he became delirious. On the 15th day, there were severe rigors. The fever and delirium continued, the patient gradually sank, and died on the 19th day after the operation. At the autopsy it was found that the edges of the wound were granulating, but that its cavity was filled with foul pus. There were no thrombi in the veins; no lesions in the viscera.

In such cases as these, it seems evident that the cause of the symptoms is the condition of the wound, and this condition in turn seems to be due to putrefaction. There appear to be only two probable explanations of the way in which the condition of the wound can produce constitutional symptoms: either some morbid material is absorbed from the wound, and poisons the system; or the mere presence of such an unhealthy wound is sufficient. It seems that if it is a poison which is absorbed, this poison does not multiply after absorption, for the symptoms only continue while the wound remains unhealthy, and the severity of the symptoms is in proportion to the amount of putrefying tissue. If the patient dies, no lesions are found except the unhealthy wound, and perhaps thrombi in some of the veins.

The indications for treatment seem to be evident, to remove the putrefying tissues; or, if this cannot be done, to adopt such local treatment as will stop the putrefactive process.

III. There are cases in which the original wound is very small, but in which some foreign substance appears to be introduced into the body through the wound, and to act as a poison. The most marked examples of such cases are some of the so-called dissecting wounds.

It has long been known that the worst dissecting wounds are those received in examining a body in which decomposition has not commenced, and that the bodies of those dying with acute peritonitis are especially dangerous. It is also known that a small puncture or scratch is sufficient for the infection.

The symptoms do not appear until several hours after the infliction of the wound. Then there are rigors, a febrile movement, and marked general prostration. There will be a little redness about the wound, and inflamed lymphatics extending up the arm. A general, unhealthy inflammation of the arm follows, the patient passes into a typhoid condition, and dies in from ten days to three weeks.

Cases similar to these are observed, in which we are unable to discover the source of the infection:—

A man, twenty-six years old, a porter by occupation, received a slight lacerated wound of the left forefinger nine days before his death. It was not known in exactly what way the injury had been received. Six days before death, the left hand, forearm and arm became swollen, as did also the axillary glands; there were fever and marked prostration. The fever continued, the patient vomited constantly, passed into a typhoid condition, and died. At the autopsy there was found diffuse, unhealthy inflammation of the connective tissue of the hand and arm, and of the axillary glands. There were red infarctions in the right lung, and in one of the kidneys.

Similar cases are also seen after operations:—

A child, seven years old, had the knee resected for the relief of a chronic inflammation. The wound was dressed antiseptically, and there was no odor in the discharge at any time. The patient began to vomit on the day after the operation, and continued to do so. The temperature was never above 101°; and fell to 96.2° before death. The leg became swollen; the patient became cold, cyanotic, and pulseless, and died on the fifth day after the operation. There were no lesions except a slight swelling of the liver, spleen, and kidneys.[1]

[1] Report of the Committee of the London Pathological Society. Transactions, vol. xxx. 1879.

In such cases as these, it seems evident that the cause of the general infection does not reside *in* the wound, but is received into the body *through* the wound. It also seems probable that the poison thus taken into the system, is capable of multiplication after being absorbed; for there is no proportion between the symptoms and the amount of poison which can have been absorbed by the wound. There is only the single inoculation, but the symptoms continue, and become more marked. In most of these cases, the symptoms do not immediately follow the inoculation, but there is a period of several hours which intervenes between the receipt of the injury and the development of the symptoms. It seems probable, therefore, that the poison is an organism, capable of multiplying itself in the body.

After death from such a cause, there are no characteristic lesions; but there may be early decomposition, staining of the endocardium by the coloring matter of the blood, a large soft spleen, and degeneration of the cells of the liver and kidneys.

IV. There is a very large class of cases which it is difficult to classify. They are the ordinary hospital cases of compound fractures and surgical wounds. It is difficult to tell whether a poison derived from without and taken up by the wound, or a poison developed in the wound, or the formation of thrombi in the veins, is to be looked upon as the efficient cause; or whether different causes may combine in the same case. The symptoms are familiar to every surgeon. Within a few days, sometimes not until after two or three weeks, from the time the patient received the original injury, he develops a febrile movement, rigors, sweating, great prostration, rapid emaciation, vomiting, diarrhœa, delirium, and jaundice. The tongue becomes dry and brown, the breath has a peculiar sweetish odor, the pulse is rapid and feeble, and the patient dies exhausted. [The irregularity and absence of periodicity in the chills, and the great variations in temperature, which range over 10° or 11° F., may be looked upon as of diagnostic value.]

After the death of these patients, there is a considerable variety in the post-mortem appearances:—

(1) There are cases in which there are no recognizable lesions.

(2) There are cases characterized by early decomposition; post-mortem staining of the tissues; congestion of the lungs, stomach, intestines, and kidneys; extravasation of blood in the serous membranes; swelling of the solitary and agminated glands in the small intestine; swelling of the spleen; degenerative changes in the cells of the liver and kidneys.

(3) There are cases in which we find localized inflammations. The parts most frequently inflamed are the joints, the connective tissue around the joints, the pleuræ, the pericardium, the peritoneum, the pia mater, and the connective tissue in different parts of the body. These local inflammations are of a purulent character, except in the serous membranes, where the principal inflammatory product may be fibrine.

(4) There are cases in which the veins in the neighborhood of the wound contain softened and puriform thrombi; there are no infarctions in the viscera, but in some cases local inflammations of the joints and serous membranes.

(5) There are cases in which the veins contain thrombi; there are infarctions and abscesses in the viscera; and local inflammations of the joints and serous membranes are also present, or may be absent. The thrombi are formed regularly in the veins in the neighborhood of the wound; sometimes, however, they are found in veins at a distance from the wound; sometimes, although the infarctions and abscesses are present, the thrombi cannot be discovered. The veins may be distended by the thrombi, or may only contain

Lung showing pyæmic (metastatic) abscesses
in various stages.

Section of liver showing pyaemic, or metastatic abscesses.

small coagula. The thrombi look like fibrine which has been coagulated some time, of a coarse, granular texture, whitish, reddish, or mottled; or they are partly softened into a reddish, sticky fluid; or they are softened into a yellowish, puriform fluid mixed with micrococci; or they putrefy with the growth of bacteria and the evolution of gases. Weigert has described small thrombi, adherent to the walls of the veins, composed of bacteria alone. There are usually inflammatory changes in the wall of the vein which contains the thrombus, especially if the thrombus degenerates and softens.

Portions of the softened thrombi may become detached, be carried into the circulation, and finally become lodged in some artery or capillary. After becoming lodged in this way, such portions of thrombi may act only mechanically, by obstructing the circulation of the blood; or may also act as local irritants, setting up a zone of inflammation about them. It is the softened, puriform, bacteritic thrombi from which such *infectious emboli* are derived. The *mechanical emboli* produce the so-called *infarctions*, especially in the lungs the spleen, and the kidneys. These infarctions are small, wedge-shaped portions of the affected viscus, usually situated near the surface, with the large end of the wedge outwards. They are of a dark red color, or decolorized at the centre, or white, or softened and broken down. The red infarctions are produced by a congestion of the bloodvessels, and an infiltration of blood into the tissue. This congestion and infiltration are due to a regurgitation of venous blood, and a change in the walls of the vessels (Cohnheim); or to a supply of blood from collateral vessels which is not carried off by the veins (Litten). The white infarctions are portions of tissue which are undergoing slow, necrotic changes as a result of their loss of blood supply (Litten).

The *infectious emboli* produce abscesses of various sizes. Such abscesses are found most frequently in the lungs and liver, but they may also occur in the brain, heart, and other viscera. The abscesses are of irregular, globular shape, and may be situated in any part of a viscus.

The portions of thrombi in the veins, which become detached, must of course pass into the right heart, and from thence into the lungs. It has always been a question how such fragments of thrombi can find their way into the aortic system of arteries, especially in those cases in which no infarctions or abscesses are found in the lungs. The ordinary explanation is that some of the portions of thrombi are small enough to pass through the vessels of the lungs, and so find their way into the left heart; and that in other cases secondary thrombi are formed in the lungs, from which fragments are detached and pass into the left heart. It is also possible that small aggregations of bacteria may find their way from the veins, through the lungs, into the left heart.

It is the rule that abscesses in different parts of the body are found in those cases in which no thrombi can be demonstrated in the veins, and that infarctions in the lungs alone, are found in those cases in which thrombi can be demonstrated in the veins. Bacteria and micrococci are usually present in the wound, in the puriform thrombi, and in the abscesses. In the blood, during life, they seem to be sometimes present, sometimes absent.

Treatment of Pyæmia.

There seems to be no question that the only successful plan of treating these cases of pyæmia is a preventive one. When the symptoms are once fairly developed, treatment is of no avail. It is indeed possible for patients to recover from the disease, but this seems to be due to their natural powers of resistance, rather than to any treatment.

[The editor feels bound to say that this view appears to him unduly fatalistic. While cases of *acute* pyæmia terminate unfavorably under any mode of treatment, and while the resisting power of the patient is no doubt of prime importance in all cases which end in recovery, yet something may be done by treatment in *subacute* and *chronic* cases, to avert the fatal issue. The hygienic condition of the patient should, if possible, be improved, and great attention should be given to careful nursing and systematic feeding. Very free stimulation should be employed—half an ounce or an ounce of brandy may be given every hour, or an equivalent quantity of wine—and the oil of turpentine and carbonate of ammonium may also be administered with advantage. But the most valuable single remedy is quinia, which may be given in large doses—from one to five grains every hour—and may be suitably combined with small quantities of digitalis and opium.]

It is a just claim of modern surgery that these forms of pyæmia can be in great measure prevented, and the mortality after injuries and operations thus greatly diminished. The success attained in preventing these forms of pyæmia seems to depend on two causes: (1) The steady improvement which has been taking place in the methods of operating, in the general management of the patients, and in the hygiene of hospitals; and (2) The use of carbolic acid as a local application to wounds.

The first cause has been a progressive one, and has been due to the efforts of many surgeons. Sir James Paget estimates that during his surgical practice of 30 years, the mortality after surgical operations has diminished from 15 per cent. to less than 5 per cent., simply from these causes.

The use of carbolic acid as a local application to wounds is almost entirely due to the teachings of Mr. Lister. This method of dressing, however, was adopted by Mr. Lister as a result of a certain theory concerning the causes of pyæmia. This theory is based on three hypotheses: (1) The local inflammatory processes and the general febrile disturbances which follow wounds are due to putrefaction of the discharges of those wounds. (2) This putrefaction of the discharge is brought about by the growth of organisms. (3) These organisms gain access to the wounds from the air. The object of treatment, therefore, is to destroy any organisms already existing in a wound, and to prevent organisms from the air entering a wound during or after an operation. To accomplish these results, Mr. Lister has devised a system of dressing based on the use of carbolic acid. This system, as described by Mr. MacCormac, is, when thoroughly carried out, practised as follows:—

If an operation is to be performed, the adjacent surface must be shaved, and then thoroughly washed with a five per cent. solution of carbolic acid. The actual steps of the operation are conducted in a carbolized atmosphere, produced by a jet of steam mingled with a five per cent. solution of the acid. The sponges employed, the hands of the operator and those of his assistants, are thoroughly purified in a five per cent. solution, previous to the operation, and again and again during its progress. The instruments are kept ready in a three per cent. solution, which may also be used for washing the wound and the sponges. All bleeding points must be carefully secured either by torsion, carbolized gut, or carbolized silk, the ends of the ligatures being cut short. The sutures should be both deep and superficial; the former of wire, the latter of catgut. The entire surface of the wound should be brought into apposition. Drainage tubes should be inserted, in order that bloody serum may escape externally. They should be removed as soon as their function is at an end. A sufficient number of tubes having been inserted, the projecting portions are cut off level with the surface, and a layer of protective silk applied to the wound. Over this are placed several layers of carbolized gauze, wrung as dry as possible out of a two and a half per cent. solution of carbolic acid, and fastened to the surface with a carbolized bandage. Over this is applied an eight-fold layer of dry gauze, a piece of mackintosh being interposed between the last layers of the gauze. In all cases the first dressing is the most important.

Attempts to replace carbolic acid by any of the other germicides have not been successful.

The success of this plan of treatment has been very great. Hospitals, especially in Germany, which were previously mere pest-houses, now give good surgical statistics. Its disadvantages are the trouble, time, and expense involved in carrying out the full system of dressings, and the possibility of poisoning the patient by too much carbolic acid. For this reason, many surgeons have discarded the complete Listerian system of dressing, and use carbolic acid as a local application in various ways.

Perhaps the question of antiseptic dressings may be best summed up in the words of Sir James Paget:—

"I believe that, in its complete (Listerian) form, we can nearly neutralize the evil influences of unhealthy hospitals and other like sources of those infectious diseases from which arise the largest portions of mortalities after operations.

"That it has not yet reduced the death-rate to a lower level than can be attained by good sanitary arrangements, good nursing, strict care and cleanliness, quietude, and simple dressing.

"That recoveries after operations are quicker and more free from fever and other constitutional disturbances, when antiseptics are used, than when they are not used.

"That in certain groups of cases, operations may be safely done with antiseptics which, without them, would be very hazardous."

Prolonged Suppuration.

There are cases of prolonged suppuration which are usually classed with pyæmia. There is first a wound, or a bruise, or an idiopathic, suppurative inflammation. This original focus of inflammation is of a purulent character, and shows no disposition to heal. After a time, successive abscesses are formed, without visible cause, in the connective tissue in different parts. These new abscesses all show the same disposition to continue to suppurate and not to heal. The patient loses flesh and strength; there is a febrile movement; bronchitis or broncho-pneumonia may be developed, and the patient finally dies in a condition of extreme emaciation. After death, abscesses are found in different parts of the body, but not in the viscera. Infarctions and thrombi do not belong to this condition. The lungs show the lesions of bronchitis and broncho-pneumonia. The liver, spleen, and kidneys are often waxy.

A man, twenty years old, was admitted to the Roosevelt Hospital, February 18, 1880. Five months before his admission, his right testicle had become swollen and painful. This epididymitis had come on one month after sexual intercourse, but had not been preceded or accompanied by gonorrhœa. On February 15, he had begun to have pain, tenderness, and redness, along the femoral vessels on the left side, with nausea, vomiting, fever, and delirium, but no rigors. On February 18, the right epididymis was swollen and tender; the lymphatic glands in the left groin were swollen and tender; there was an erythematous blush over the anterior surface of the left thigh; there was tenderness, but no induration, along the course of the left femoral vessels; there was fever. By February 27, the lymphatic glands in the left groin had suppurated; the abscess was opened, but it was found that the pus had burrowed down the anterior surface of the thigh. On March 24, an abscess in the right epididymis was opened. By April 4 an abscess had formed in the right inguinal region, and by April 23, one above the spine of the scapula. On April 29, an abscess had formed above the right clavicle, and on June 5 the patient died.

At the autopsy, the abscesses were found as mentioned, but no thrombosis of any veins. There was purulent broncho-pneumonia, and commencing waxy infiltration of the liver, spleen, and kidneys.

Spontaneous Pyæmia.

Under this name we include a group of obscure cases, which resemble ordinary pyæmia in their symptoms and lesions, but are of obscure etiology. They do not begin with a wound, or bruise, or abscess.

An individual, without known cause, will be seized with rigors followed by a febrile movement, and marked prostration. There may be vomiting, or diarrhœa, or cough. Sometimes ecchymoses or pustules appear in the skin. Usually headache and delirium are present. The patients die in a typhoid condition. At the autopsy, lesions are found like those of pyæmia: abscesses and infarctions in the lungs and kidneys; suppurative inflammations of the joints and connective tissue.

A girl, ten years old, after playing in the snow, was seized with rigors, followed by a febrile movement, and with pains all over the body. The fever continued; she became delirious; the pain was most intense in the right hip. She passed into a typhoid condition and died on the ninth day. At the autopsy, the right pleural cavity was found half full of purulent serum, the left pleura coated with fibrine, and both lungs studded with hemorrhagic infarctions. The kidneys contained infarctions; there was a small abscess under the scalp; both hip-joints and one sterno-clavicular articulation contained pus.

A man, forty-seven years old, of intemperate habits, was attacked twenty-six days before his death with headache, loss of appetite, and a general tenderness over the muscles; but was not confined to bed. Eleven days before his death, rigors, a febrile movement, diarrhœa, and pain in the chest came on. He was now so ill that he was confined to bed. Eight days before death he became delirious, and continued so. After this the temperature was from 103°–107° F., the breathing from 42–48, the pulse from 112–120. There were no physical signs except a double aortic and a mitral systolic murmur. There were a few red spots in the skin, on the upper part of the abdomen. The patient passed into a typhoid condition, and died.

An autopsy was made three hours after death. The brain was not examined. The heart showed the aortic and mitral valves to be thickened and insufficient, but not roughened; the left ventricle was hypertrophied; the heart cavities were empty. The larynx and pharynx were normal. The lower two-thirds of the trachea, and the larger bronchi, were congested; their mucous membrane was coated with a layer of tenacious muco-pus. The small bronchi were full of pus. The upper lobes of the lungs were inflated and dry, the lower lobes were congested. The liver appeared normal. The spleen was large and soft. The stomach and intestines were normal. The kidneys were large; in the cortex were numerous small white foci, surrounded by red zones. These white foci were formed of pus; the glomeruli in the foci contained colonies of micrococci. The bladder was normal.

[The reader may consult with advantage papers by Dr. Samuel Wilks, on "Pyæmia" and "Arterial pyæmia," in Guy's Hospital Reports, 3d s., vols. vii. and xv.]

HYDROPHOBIA AND RABIES; GLANDERS; MALIGNANT PUSTULE.

BY

WILLIAM S. FORBES, M.D.,

DEMONSTRATOR OF ANATOMY IN THE JEFFERSON MEDICAL COLLEGE; SENIOR SURGEON TO THE EPISCOPAL HOSPITAL, PHILADELPHIA.

Hydrophobia and Rabies.

Hydrophobia is a general malady which manifests itself chiefly through disturbances of the nervous system, of an intensely distressing character. The word hydrophobia (ὕδωρ water and φόβος fear) signifies dread of water, a name suggested by the inability to swallow liquids, which forms one of the most prominent and marked features of the disease as it exists in man. In consequence of the occasional absence of this striking symptom, and of its occasional presence in other diseases, the name has been objected to, and the word *rabies*, which is the term applied to the corresponding affection met with in the lower animals, has been sometimes substituted instead. It may be well, however, to retain the name hydrophobia at present, as it is the one by which the disease is most widely known.

Cause of Hydrophobia.—The primary or exciting cause of hydrophobia may be said to be the inoculation of the body with a poison of a specific character, which is generated or at least contained in the salivary fluids or secretions from the buccal and faucial mucous membranes of an animal which is affected with rabies, the virus being introduced upon the animal's teeth, or possibly by its lips or tongue. It is not necessary that there should be an actual bite, but an abraded surface must exist, in order that inoculation shall be effected. Hydrophobia is apparently produced by the action of this specific poison upon the respiratory centres of the nervous system, producing a morbid irritability of the medulla oblongata, and of the eighth pair of nerves of Willis's classification.

Rabies originates in certain animals, such as the dog, the wolf, the fox, the skunk, the jackall, the cat, and the badger. The disease does not originate in man, and it is not sure that it can be communicated from one human being to another. But animals in whom the virus does not originate, are yet susceptible to hydrophobia, and all are probably capable of transmitting it when under its influence. Magendie inoculated two dogs with the saliva of a man suffering from hydrophobia; one of the dogs became mad and bit two others, one of which also became mad and died. The malady has been provoked in dogs by inoculating them with the saliva of rabid horses and asses, and cases have been reported of human beings having acquired hydrophobia from the bites of rabid horses and pigs. Rabbits and similar animals, as well as fowls,

soon die from inoculation of this poison, without manifesting the ordinary symptoms of rabies.

It is well known that many persons bitten by rabid animals do not contract hydrophobia, the morbid matter being no doubt wiped off as the teeth penetrate the clothes. Hence the wounds inflicted by rabid wolves are much more dangerous than those received from rabid dogs; the difference being apparently due to the fact that wolves generally bite the exposed parts of the body, such as the face, neck, and hands, whereas dogs usually seize with their teeth those parts that are covered. Sir Thomas Watson writes that of 114 persons bitten by rabid wolves, 67 died of hydrophobia.

Bouley gives the following summary of facts, collected from the report made to the Consulting Committee of Public Hygiene, France:—

(1) In 49 departments wherein cases of rabies were reported by 108 communications, 320 persons were bitten by rabid animals. This figure is enormous, but must be regarded nevertheless as far below the truth—for there are departments where the disease is common, from which no reports were obtained.

(2) Out of 320 cases of persons bitten, the bites caused hydrophobia in 129, or a proportion of about forty per cent.

(3) Out of 320 cases of persons bitten, the wounds were not followed by the disease in 123 known and specified cases. The established rate of exemption would, therefore, seem to be about 38 per cent.

(4) Among the 320 bitten persons, 206 were males and 81 females, while in 33 cases the sex was not mentioned. With reference to the distribution of cases throughout the year, the author mentions the following facts:—

During the three spring months, March, April, and May, 89 cases occurred; during the summer months, June, July, and August, 74 cases; during the autumn months, September, October, and November, 64 cases; and during the winter months, December, January, and February, 75 cases. This leads to the conclusion, that there is no great difference in the number of cases between the seasons; that the danger from mad dogs in the winter season is about the same as in the heat of summer; and that in the spring cases are most frequent, and in the autumn least frequent. The popular opinion, which regards winter as free from the curse of hydrophobia, and which indicates that the disease exists in summer more than at any other season, has no foundation in fact.

This brings us to a conclusion of great importance, namely, that as far as sanitary measures, and the protection of the people are concerned, we should, at all times and in all seasons, be equally on our guard, and should take efficient measures of protection against dogs. Hydrophobia is not peculiar to any age—it prevails in all countries and in all climates. It is possible that idiosyncrasy may exert an important influence in preventing the effects of the poison. It is well known that this is true of other zymotic poisons.

This influence of idiosyncrasy may be illustrated by the experience of Dr. Hertnich, of Berlin, who inoculated fifty dogs with saliva taken from another dog affected with rabies, and not one in five was affected.

Rabies in the Dog.—The disease as it affects the dog, has been well described by Mr. Youatt, and, as his description has become classical, I make the following extracts:—

In the greater number of cases there are sullenness, fidgetiness, and continual shifting of posture. When I have had opportunity I have generally found these circumstances in succession. For several successive hours perhaps he retreats to his basket or his bed. He shows no disposition to bite, and he answers the calls upon him laggardly. He is curled up, and his face is buried between his paws and his breast. At length he begins to be figdety. He searches out new resting-places, but he very soon changes them for others. He takes again to his own bed; but he is continually shifting his posture. He begins to gaze strangely about him as he lies on his bed. His countenance is clouded and suspicious; he comes to one and another of the family, and he

fixes on them a steadfast gaze, as if he would read their very thoughts. "I feel strangely ill," he seems to say: "have you anything to do with it? or you? or you?" Has not a dog mind enough for this? If we have observed a rabid dog, at the commencement of the disease, we have seen this to the very life. . . . .

The disease manifests itself under two forms: the *furious form*, characterized by augmented activity of the sensorial and locomotive systems, a disposition to bite, and a continued peculiar bark. The animal becomes altered in habits and disposition; has an inclination to lick or carry inedible substances; is restless and snaps in the air, but is still obedient and attached. Soon there are loss of appetite and the presence of thirst, the mouth and tongue swollen; the eyes red, dull, and half closed; the skin of the forehead wrinkled; the coat rough and staring; the gait unsteady and staggering; there is a periodic disposition to bite; the animal in approaching is often quiet and friendly, and then snaps; latterly, there is paralysis of the extremities; the breathing and deglutition become affected by spasms; the external surface is irritable, and the sensorial functions are increased in activity and perverted; convulsions may occur. These symptoms are paroxysmal, they remit and intermit, and are often excited by sight, hearing, or touch. The *sullen form* is characterized by shyness and depression, in which there is no disposition to bite, and no fear of fluids. The dog appears to be unusually quiet, is melancholy, and has depression of spirits; although he has no fear of water, he does not drink; he makes no attempt to bite, and seems haggard and suspicious, avoiding society and refusing food. The breathing is labored, and the bark is harsh, rough, and altered in tone; the mouth is open from the dropping of the jaw; the tongue protrudes, and the saliva is constantly flowing. The breathing soon becomes more difficult and laborious; there are tremors, and vomiting, and convulsions.

Incubation of Hydrophobia.—The wound by which the poison is conveyed within the body generally seems to heal without any trouble, and the virus may lie concealed for a period of very variable duration, the length of which has been estimated as ranging from three days to seven years. Watson thinks that the virus may be inclosed in a nodule of lymph, or detained in temporary union with some of the tissues, until some exciting cause sets it free upon its errand of destruction. Virchow compares the action of the poison to that of a ferment producing through the medium of the circulation its specific effect upon the nervous system. Trousseau says that the disease generally shows itself in man from one to three months after inoculation; that cases are rare after three months; and that the authenticity of cases reported as occurring after the lapse of a year may well be disputed. [Féreol has, however, reported an apparently authentic case in which the period of incubation was two and a half years.]

Age influences the period of incubation, this being shorter in young people than in old. Fleming tells us that from an estimate of ages from three to twenty years, and from twenty to seventy-two years, it has been found that for the first group there is a mean period of incubation of forty-four days, and for the second group of seventy-five days. Faber adopted the view that the contagious principle became encysted on its introduction into the body, and that it entered the blood subsequently under the influence of favorable conditions.

Dr. Anthony Todd Thompson,[1] in speaking of rabies from the bite of a cat, says that the virus continues dormant in the part into which it is introduced by the bite of the animal, until a certain condition of the system renders the nerves in the vicinity of the wound susceptible to the influence of the poison, and that this being communicated, a morbid action is begun in these nerves, and extended to those which preside over respiration, thus inducing the whole train of symptoms which constitute the disease.

[1] Medico-Chirurgical Transactions, vol. xiii. 1826.

Symptoms of Hydrophobia.—The symptoms vary with the peculiar idiosyncrasies of the person inoculated, and hence no detailed account of them can be given, which shall apply accurately or even approximately to each individual case.

Dr. Dolan says that there exist but two periods in this disease: (1) that of incubation, and (2) that of development, including all the phenomena between the first symptom and death; but Virchow has divided the symptoms of the second period into several distinct stages.

Symptoms of the First Stage.—In the first stage of the period of development, there are uneasiness and restlessness, with stiffness around the neck and throat, often nausea and vomiting, and cerebral symptoms, consisting of headache and mental excitement. These symptoms, however, are not of invariable occurrence, for the patient is sometimes suddenly seized with difficulty of swallowing liquids. Local symptoms are sometimes observed, but in other cases may be entirely wanting. Irritation of the scar and of the tissues in the vicinity of the wound, accompanied by darting pains of a rheumatic character, is one of the most persistent symptoms. The cicatrix often becomes red and inflamed; and if the wound is still open, it presents an unhealthy appearance, and the discharge becomes thin and ichorous.

The mental and moral condition is at the same time changed, the patient being in some instances troubled and anxious about the wound, and very commonly becoming irritable and ill-tempered.

Poland remarks that there often exists a characteristic anxiety, attended with pain in the præcordia and a sense of weight and pressure on the chest. The sleep may be disturbed and broken; the patient suddenly starting up in a frightful dream, and again sinking back in a state of mental depression and gloom. There is loss of appetite, no desire for swallowing, a feeling of clamminess in the mouth, with sighing and oppression, the patient breathing with unusually deep inspirations. There are attacks of chilliness, with a highly impressible state of the system; there is a feeling of having taken cold; the voice is rough; there is a sensation of languor and lassitude, with great weakness and heaviness, and sometimes slight convulsive movements of the face and limbs; there is a remarkable susceptibility to atmospheric impressions, the slightest contact of cold air being a source of great torture by producing a feeling of suffocation. The poison is now fairly at work, and in a few hours, generally from ten to twenty-four, explodes with frightful violence. The period of latency is now past, the disease has reached its second stage; the difficulty of swallowing and the dread of water fully establish the presence of hydrophobia.

Symptoms of the Second Stage.—The second and specific stage usually follows the first, but sometimes occurs without any preliminary warning; it begins with stiffness and pain in the muscles of the jaw, throat, and base of the tongue.

Hyperæsthesia of the parts supplied by the eighth pair of cerebral nerves, is now manifested by the convulsive spasms of the muscles of the throat, which cause every attempt at deglutition to be attended with pain and difficulty. Hence the great dread of food, and particularly of fluids. There is a distressing dryness of the mouth and throat, often accompanied by a sensation of extreme thirst which cannot be relieved. The secretions of the mouth and pharynx are at first frothy, but soon become viscid, and cannot be ejected without great trouble, a hawking and barking noise being often produced in the attempt. The violence with which the patient spits is a striking phenomenon. Before long the disease involves the muscles of the general sys-

tem, through the medium of the spinal and cerebral nerves, giving rise to convulsions which may simulate those of tetanus or of epilepsy. In this stage of the disease the pulse is rapid and quick, reaching one hundred and thirty, while the temperature rises to one hundred and two, and often to one hundred and five degrees Fahrenheit.

There is frequent micturition; the urine is at first limpid, but afterwards becomes red and sanguinolent, and flows in small quantity. It contains renal epithelium and much albumen. It is usually acid in its reaction, and contains an abundance of earthy phosphates and carbonates. Heated in a tube and cleared of the albuminous precipitate, caustic potassa and the cupro-potassic fluid discover reactions which reveal the presence of sugar. This, according to some authorities, indicates congestion of the brain and spinal cord as well as of the kidneys.

The patient's senses now become unnaturally acute; the surface of the body is excessively irritable; the sight and sound of fluids aggravate the already exasperated condition; and sometimes the slightest puff of air, or even the smell of particular substances, will induce a paroxysm.

The mind is in a singular condition of fear and anxiety, and the patient experiences a dread of everything which is either seen or imagined, culminating in a state of unutterable despair, or sometimes of furious anger. There is usually almost complete insomnia, and the patient is often unnaturally talkative. There may be insane impulses and delusions, with sometimes, it is said, an inclination to bite. The features have a wild and anxious look; the brows are firmly knit; the eye is staring; the angles of the mouth are drawn; and the whole appearance is intensely haggard and ghastly.

As the disease advances, both the frequency and the severity of the paroxysms are augmented, and the mental state borders upon mania. After each paroxysm there is great prostration. The duration of this second stage varies from twenty-four to forty-eight hours; seldom longer.

Symptoms of the Third Stage.—The third is the paralytic and last stage of the disease. It is marked by the occurrence of rapidly increasing depression and exhaustion, with subsidence of the paroxysms; the pulse is now small, quick, and often irregular; the skin is covered with a clammy sweat, the eyes look dull and sunken, and the pupils are dilated. The patient rapidly emaciates; the mouth hangs open, allowing the saliva to escape, or if it flows backward into the throat, it causes a gurgling noise, and gives rise to a feeling of suffocation and choking. Death may take place from asphyxia during a convulsive paroxysm, or may result simply from exhaustion.

All the symptoms have been known to abate, and the patient to sink into a state of repose and expire immediately on waking. The duration of hydrophobia—that is, of its period of development—varies from three to six or seven days, or in some cases even longer. It has been fatal in sixteen hours, but death generally occurs on the third or fourth day.

The foregoing description of the symptoms of hydrophobia is based upon the writings of Poland, Tanner, Fleming, Dolan, Virchow, and other authors who have had practical experience in the treatment of the disease. To use the language of Bigelow, "In fact one description is the copy of another."

Morbid Anatomy of Hydrophobia.—Dr. Dolan writes that on the 15th of May, 1877, Dr. Gowers exhibited before the Pathological Society of London a series of microscopic sections, illustrating the structural changes in the medulla oblongata and spinal cord in four cases of rabies.

In all four cases the vessels of the gray matter were greatly distended, the distension being greater in the medulla near the gray nuclei, in the lowest part of the fourth

ventricle. In three of the cases, the larger veins in this position presented aggregations of small cells within the perivascular lymphatic sheath. . . . . Similar cells were scattered through the tissue, among the nerve elements, and in some places, chiefly in and near the hypoglossal nuclei, there were dense collections of these cells, constituting in fact miliary abscesses. Similar smaller collections were seen among the fibres of origin of the hypoglossal and glosso-pharyngeal nerves.

In the paroxysms of hydrophobia, the respiratory apparatus is wholly engaged, and in Dr. Gowers's cases the structural change was especially well marked in the region of the "respiratory centre," in the medulla; and in the case in which the change was most decided the diaphragm had been violently affected.

[Changes in the medullary and spinal cord, analogous to those observed by Dr. Gowers, have also been noted by Clifford Allbutt, and by Cheadle. Benedikt, of Vienna, and Wassilief, of St. Petersburg, have found inflammatory changes in the brain, while Nepveu has noticed congestion of the nerve-structures in the neighborhood of the wound, and inflammatory lesions in the salivary glands. Coats, of Glasgow, has observed hyperæmia of the kidneys, with an accumulation of white corpuscles. The only characteristic macroscopic change, according to Cooper Forster, is dilatation of the pharynx.]

Dr. Bigelow states that the structural changes noted in hydrophobia are not *essential* and *primary* factors in developing the train of symptoms, but are in all probability *secondary lesions*, resulting from the terrible disturbance which the disease causes in the functions of the respiratory, vascular, and nervous systems. Such phenomena can hardly, therefore, be of any value in determining the pathogeny of the affection. He adds that though we have acquired new and important data by these observations, still we cannot affirm positively that we have found a characteristic lesion pathognomonic of hydrophobia. [Middleton, of Glasgow, entertains a similar view.]

It has been conjectured, according to Dr. Hammond, that hydrophobia may begin as a blood disease, and end as a nerve disease. "The nature of the hydrophobic virus is unknown. It is probably of the nature of a ferment;" Dr. Barry, on the other hand, in his *Experimental Researches*, rejects the idea that the poison of hydrophobia is absorbed and mingled with the blood, as being directly opposed to all analogy.

Diagnosis of Hydrophobia.—Dr. Dolan well says that the symptoms of hydrophobia are so characteristic that they should not be confounded with those of any other disease. To distinguish it from tetanus, Drs. Holland and Shinkwin point out the following differences:—

(1) Tetanus results from injuries of the most varied character.

(2) In tetanus the effects follow in a very short space of time, a week seldom elapsing between the injury and the development of the symptoms, while in the one hundred and twenty cases of hydrophobia collected by Dr. Holland, the shortest interval recorded between the bite and the first symptoms of rabies was twelve days, the longest three hundred and thirty-four days, and the average sixty-one days and eighteen hours.

(3) The anxiety, horror, and convulsions at the sight of fluids, are not found in tetanus.

(4) In tetanus, some of the muscles are often in a state of rigidity, and the convulsions occur at much shorter intervals than in cases of rabies.

(5) Delirium is a very rare symptom in tetanus, and a frequent one in rabies, having occurred eighty times in one hundred and twenty cases.

(6) In tetanus, the secretion of saliva is seldom increased.

(7) In tetanus, the muscles of the lower jaw are frequently in a state of tension.

(8) Opisthotonos or emprosthotonos often terminates the case in tetanus.

(9) As Fleming remarks, while physiologically tetanus is a disease of the true spinal system of nerves, rabies involves the brain also, as is evinced by the disorder of the intellectual functions and special senses even early in the disease.

To distinguish hydrophobia from œsophagitis, Dr. Holland points out these essential differences:—

In Œsophagitis.	In Rabies.
1. Pain in the pharynx, throat, or along the spine occurs as the earliest and invariable symptom.	1. Pain in the pharynx, throat, and along the spine, occurred in forty-two out of one hundred and twenty cases, or about once in every three cases, and not as the earliest symptom.
2. The attempt at swallowing solid food causes intense pain, and in aggravated cases swallowing of even fluids is accompanied by pain, or may be totally impossible.	2. The attempt to swallow fluids, though not generally accompanied by intense pain, causes dyspnœa, convulsions, etc., while solids can be in most cases taken with comparative facility.
3. Horror of fluids reported to have occurred in one case.	3. Horror of fluids the most prominent symptom in one hundred and nineteen out of one hundred and twenty cases.
4. The amount of difficulty in swallowing is in direct proportion to the extent and intensity of the pathological appearances found in the œsophagus.	4. No direct relation exists between the pathological state of the œsophagus shown after death, and the intensity of the dysphagia.
5. Saliva abundantly secreted, expectoration difficult, and the time of the occurrence of these phenomena not fixed.	5. Saliva secreted in great quantity, often flowing spontaneously from the mouth; these symptoms often occur among the last phenomena.
6. Urgent thirst in perhaps all cases.	6. Thirst was urgent in about one-third of the cases.
7. Average duration of the disease seven days.	7. Average duration of the disease seven days.
8. Generally terminating in recovery.	8. Invariably terminating fatally.
9. Death caused by œdema of the glottis, gangrene, or rupture of the œsophagus.	9. Death most probably resulting from asphyxia, coma, or relapse.

Fleming says: Indeed it is not possible to mistake hydrophobia for any other malady, or to doubt its existence when it is present; for if, during the stage of incubation, doubts and fears exist, all uncertainty comes to an end when the disease really appears.

Prognosis of Hydrophobia.—Hydrophobia is regarded as one of the gravest of all the maladies which afflict humanity. It has been asserted that we have no well-authenticated instance on record of a cure of this disease. Yet, Dr. Dolan says that the evidence of the recovery of cases of hydrophobia is as conclusive as the evidence that such a disease exists. "To deny the existence of such records of recovery, is simply to deny the existence of the disease. We can only know rabies by the symptoms, and by the description we have furnished by those who have had cases under treatment. If the evidence is satisfactory and conclusive that rabies has existed, and, unfortunately, been too fatal, it is also equally satisfactory and conclusive that Dr. Offenburg has described the disease, and attended a patient who recovered, and that Dr. Austin Flint has offered similar testimony."

Dr. Bigelow says: "The experiments made with oxygen by two Russian physicians, Drs. Schmidt and Zehender, with a well-authenticated cure of a case of hydrophobia from its administration, reported in the *Lyon Médical*, inspire the hope that at last science has struck the physiological key-note,

and that in well-established instances of the disease the physician may look with a reasonable assurance to a successful termination."

TREATMENT OF HYDROPHOBIA.—The treatment of hydrophobia resolves itself into that which is preventive and that which is curative.

Preventive Treatment.—The essential influence producing hydrophobia is lodged in the fluid from the rabid animal's mouth, and not the wound made by the teeth. The first means to be employed in order to prevent the virus from entering the system is prompt *suction of the wound*, so as in this way to remove the poison from the part at once. The bitten person should do this for himself, and should wash his mouth, after spitting out its contents, with some fluid, and so by continued sucking and washing get rid of the poison as far as possible. The wound, when its situation permits, as when it is in an extremity, should be squeezed on its cardiac side at the same time; it should also be well washed. Or a strap or handkerchief may be applied tightly above the wound, and a cupping-glass be applied to the part at once, and strong suction made.

Cauterization should be practised as soon as possible, and the best possible means of cauterizing the part is with the hot iron. A knife blade, a nail, or an iron poker may be used; the iron should be heated to a white heat, and the wound throughout its entire extent should be burnt with the greatest thoroughness and in the shortest possible time after the person has been bitten.

Dr. Bigelow gives the following statement as taken from Fleming: In Algeria, out of 16 cases of immunity, in 14 the patients had the wounds inflicted by rabid animals cauterized more or less promptly; three persons were cauterized twenty-four hours after being wounded, and a fourth not for thirty-six hours. The following Table gives the details of the 16 cases:—

	CASES.
Immunity after immediate cauterization with hot iron	7
" " " with gunpowder	1
" after late appearance cauterized with hot iron	1
" after at least 24 hours	3
" " 36 "	1
" after immediate cauterization with muriate of antimony after 3 hours	1
" without adopting precautions	2

In short, immunity in one-half of these cases may be supposed to have been due to immediate cauterization, in three-eighths to tardy cauterization, while in one-eighth the patients escaped without any treatment. Hugo speaks of seven persons who were bitten by a rabid dog; three had their injuries cauterized twenty-four hours afterwards, and the four others cauterized themselves with two pieces of iron heated in the fire; all escaped. The same dog attacked a child twelve years old, and, its wounds not having been attended to, it died of hydrophobia.

Excision is strongly recommended by Foot, Fleming, Abernethy, and others. Foot gives eight cases in which excision was practised. In one case it was done at once; in another, six hours after the bite; and seventy-two hours after the bite was the longest period in which it was performed in any of the eight cases. If excision is made dangerous from the neighborhood of large bloodvessels or nerves, caustics are recommended. Nearly all the caustics in use have been recommended by different surgeons as having been successful in their hands. We must remember, however, that

the immense majority of bites will not be followed by hydrophobia under any circumstances, and, on the other hand, that hydrophobia has occurred after free excision of the injured part. Mr. Youatt had great confidence in nitrate of silver. He was himself bitten seven times, and on each occasion contented himself with freely cauterizing the wounds with nitrate of silver.

[The daily administration of large doses of *bromide of potassium*, during the whole period of incubation, is strongly recommended by Duboué, of Pau.]

Curative Treatment.—When the virus commences to evince its effects on the system, the second period, or that of development, begins, and the patient should now at once be placed in a dark room, and kept as quiet as possible, and free from all avoidable sources of irritation; his strength, too, must be supported by such concentrated food and stimulus as can be taken, or by nutritious enemata.

Dr. Watson, of Jersey City,[1] reports a case which was regarded by himself and by Prof. Austin Flint as a case of undoubted hydrophobia. In this case a sixteenth, a ninth, and a sixth of a grain of *curara* were injected subcutaneously at different times, when, after the third injection, the unfavorable symptoms abated, and the patient entirely recovered. Offenburg and Polli have also recorded instances of recovery from hydrophobia under the hypodermic use of curara. Dolan, too, gives the case of a woman, aged 24, who was bitten by a dog supposed to be rabid, in which case seven injections, each containing one-third of a grain of curara, were administered within four hours and thirty-five minutes, and the patient entirely recovered.

In a case of hydrophobia, to which I was called in consultation by Dr. Carroll, reported by myself in the American Journal of the Medical Sciences for April, 1878, the spasms were relieved by the inhalation of *nitrite of amyl*.

The case was that of a man, thirty years of age, who was bitten on January 1, 1877, on the back of his left ring-finger, by a terrier dog which was suffering from rabies. On the 20th of the following March, 79 days after the infliction of the wound, the scar assumed a red and swollen look, and an eruption appeared on the morning of the following day (March 21), disappearing on the 26th. On the morning of the 28th, the man was wild with excitement; his pulse was rapid and small, running at the rate of 140 beats to the minute; his skin was leaky and cool, and his countenance anxious. He made violent efforts to drink a glass of milk, but was utterly unable to do more than grasp at it; he could not possibly take hold of the tumbler, and entreated us in a wild convulsive manner to take it away. At this moment I gave him 25 drops of the nitrite of amyl by inhalation. By the time the evaporation of the amyl had taken place, the man said, "What is that you have given me? it is running all around my head." When two or three minutes had elapsed, his pulse was found to be 88, and his respiration quite natural; he appeared to be perfectly calm. I then asked him if he thought he could take some milk, and he said that he thought he could. The milk was brought, and he swallowed a pint with the greatest ease; he said he would take some more, when half a pint additional was given to him, with two ounces of brandy, and, when he had swallowed it, he asked one of the bystanders to give him a drink of water. The water pitcher was brought, and I poured out a full glass before him; when, taking the glass as composedly as any one could, he drank off its contents with the greatest comfort, and held the glass out for more. I filled it again, and, when he had drunk nearly all the water, he exclaimed, "Oh, but that's good!" I sat with him nearly two hours longer, during which time he was perfectly composed, and got some sleep. Then his pulse became more rapid, and his breathing more frequent. I asked him if he would take a little brandy and water. The *mere suggestion* of the brandy and water excited him very much, and, when it was brought near him, his excitement was fearful, and he exclaimed rapidly, "No, not until after breathing that stuff," as he called the

[1] American Journal of the Medical Sciences, July, 1876.

amyl. It was immediately given to him, and had the same happy effect as on the first occasion; his pulse fell, his respiration became more calm, and he took half a pint of milk, three raw eggs, and half an ounce of brandy, which he swallowed very readily and with great comfort. He then fell asleep, and I left him.

I returned the next morning at 9 o'clock, having asked Dr. John Ashhurst to see him in consultation with Dr. Carroll and myself. We found that our patient had had some sleep, but that for an hour or more he had been very much excited. He could not have a glass of water brought near him now; it was tried, and on its approach he shook convulsively. Nearly a teaspoonful of the nitrite of amyl was now administered, and he again became quite calm and drank nearly a pint of water, and soon after took some milk and eggs. At 3 P. M., however, the spasms returned, and, on attempting to give him the amyl, he exclaimed that he was choking, and immediately went into a convulsion which ended in death. No post-mortem examination was permitted.

My friend Dr. Solliday, of Tamaqua, administered the nitrite of amyl in a case of hydrophobia in a girl, aged 17, who was bitten by a spitz dog which was suffering from rabies.

The wound was inflicted on the lower lip, on Nov. 26, 1877; the wound was very slight, and healed quickly. On Dec. 20, three weeks and three days after the accident had happened, hydrophobia became manifest. The spasms came on every fifteen minutes, and the disease was well developed. In the evening, twenty-four drops of the nitrite of amyl were given by inhalation. She now complained of numbness in her extremities, and soon became very calm, and remarked that, if the room were quiet, she could sleep. At this moment a glass of water was given to her, which she swallowed without trouble. In fifteen minutes she was in a quiet sleep, which continued for four and a half hours. She was awakened by a violent storm of rain which made a great noise on the roof and shed of the house in which she lived. The spasms immediately returned, and were more violent than at any time previous, and continued until death took place, late in the afternoon of the 21st. No post-mortem examination was permitted.

In both of these cases the relief on inhalation of the nitrite of amyl was very marked, and exceedingly comforting. It relieved the spasms in both cases, so that the patients could drink both water and milk to satiety. But in neither case did the amyl appear to stay the advance of death.

In the *Lyon Médical* there is reported a case of hydrophobia in which, owing to the experiments of Drs. Schmidt and Zehenden with *oxygen*, that gas was inhaled, and the disease disappeared.

The case was that of a little girl bitten in the hand by a rabid dog. The wound, after being cauterized, healed in a few days; but a fortnight afterwards the evidences of hydrophobia were manifested. Three cubic feet of oxygen were then inhaled by the patient, and in the course of an hour and a half the distressing symptoms disappeared, and the child became calm. Two days afterwards the symptoms reappeared; there were difficulty of breathing and swallowing, and convulsions; the oxygen was again inhaled, and at the end of forty-five minutes the attack entirely subsided, and never returned.

[Other modes of treatment which have been recommended are the inhalation of ether or chloroform; the application of an ice-bag to the spine (Todd, Erichsen); the persistent employment of a primary galvanic current (Hammond); transfusion of blood (Shinkwin); and intra-venous injection of saline solutions (Culver), and particularly of bromide of potassium (Duboué). The monobromate of camphor is also credited with having effected a cure in some cases.]

Glanders.

Glanders is a contagious and infectious disease, which appears also to be sometimes spontaneously generated in the horse, the ass, and the mule, and which peculiarly belongs to those animals. While it is a general disease, affecting the whole system, it displays its greater force and virulence on the mucous linings of the nose and frontal sinuses, and on the submaxillary glands and lymphatics of the neck and ear.

In 1821, Mr. Muscroft, in an article in the Edinburgh Medical and Surgical Journal, described the disease as existing in a man who had become inoculated by the dead body of a glandered horse; and in 1840, a patient who had been admitted into St. Bartholomew's Hospital, London, died of glanders, and the nurse who had attended this patient took the disease and also died of it. Many similar cases are on record which show that the disease, though never spontaneously developed in man, can be readily conveyed to him, and that, when once inoculated, it can be easily communicated from one human being to another.

It is said that the virus may be communicated through the blood, and Viborg believes that inoculation may also take place through such secretions as the saliva, the urine, and the sweat. It is well known that the disease may be produced by wiping the hands and face with cloths which have been used on an affected horse. Bouley inoculated horses with the pus of glanders, and though the inoculated parts were cut out one minute after they were inoculated, yet the disease rapidly manifested itself. Villemin, in 1868, declared his belief that glanders and tubercle were closely allied, and that they should be looked upon as nearly related species of the same genus.

Symptoms of Glanders.—The disease manifests itself by an eruption of tubercles or nodules, and appears in two distinct forms. One of these involves the mucous membrane of the nose and the neighboring glands, and is the form which is particularly known as glanders; it is termed *morve* in France, and *Rotz* in Germany. The other form affects the superficial lymphatics and absorbents, either in the trunk or extremities, and is characterized by the development of small tumors beneath the skin, varying from the size of a pea to that of a walnut, hard, fixed, and very painful when touched. There is a corded and knotty condition of the parts, whence this form of the disease is termed *Wurm* by the Germans, and *farcin* by the French. In England it is known as farcy-buds. These two forms are but different types of the same disease, and they may be found associated in the same patient. The period of incubation or latency of glanders varies from two days to a week, after which time the stage of invasion begins.

Symptoms in the Horse.—The following description of the disease as it is observed in the horse, is taken from Youatt:—

The earliest local symptom is a nasal discharge, which consists of an increased secretion, small in quantity, and flowing constantly. It is of an aqueous character, mixed with a little mucus. It is not sticky when first recognized, but becomes so afterwards, having a peculiar viscidity and glueyness. The discharge soon increases in quantity, and, in the advanced stages, becomes discolored, bloody, and offensive. On the other hand, the discharge may continue for many months, or even for two or three years, unattended by any other symptom, and yet the horse be decidedly glandered. The glands under the jaw soon become enlarged, and are generally observed on the same side as that on which the nostril is affected; the swelling at first may be somewhat large and diffused, but this subsides in a great measure and leaves one or two glandular enlarge-

ments, which become closely adherent to the jaw-bone. The mucous membrane of the nose becomes of a dark purplish hue, or almost of a leaden color; never the faint pink blush of health, or the intense and vivid red of usual inflammation. Spots of ulceration will probably appear on the membrane covering the cartilage of the nose; these ulcers are of a circular form, deep, and with abrupt and prominent edges, and become larger and more numerous, obstructing the nasal passages, and causing a grating or choking noise in breathing. The disease extends upwards into the frontal sinuses, and the integument of the forehead becomes thickened and swollen, causing peculiar tenderness. The absorbents about the face and neck now become implicated, constituting farcy; these enlarge and soon ulcerate. The absorbents on the inside of the thigh, and then the deep absorbents of both hind legs, are next involved, causing these parts to swell to a great size, and to become stiff, hot, and tender. The constitutional symptoms are loss of flesh, impaired appetite, failing strength, and more or less urgent cough; the belly is tucked up; the coat is unthrifty and readily comes off. The animal soon presents one mass of putrefaction, and dies exhausted.

Farcy as met with in the horse is, according to Mr. Youatt, but a different type of the same disease.

Farcy is an affection of the absorbents and their glands, usually attacking the extremities. It begins in a kind of glanderous chancre, or ulcer, and, as the virus passes along the absorbent vessels, these suffer from its acrimonious quality; hence the *corded veins*, as they are called by the farrier, or more properly the thickened and inflamed absorbents following the course of the veins. At certain distances in the course of the absorbents are valves, and these belly out, and impede or arrest the progress of the matter towards the chest. The virus at these places causes swellings, which are very hard, more or less tender, and with perceptible heat about them. They are observed about the lips, nose, neck, axillary spaces, and thighs. Suppuration and ulceration next ensue. The ulcers are rounded, with elevated edges and pale surface; and discharge a virus as infectious and as dangerous as the matter of glanders. While they remain in their hard aud prominent state, they are called *buttons* or *farcy-buds*, and they are connected together by the inflamed and corded absorbents. The constitutional symptoms are drooping, impaired appetite, loss of flesh, and a staring or prominent coat. The horse may then rally and appear to be restored to health, but by degrees the affection becomes general; the millions of capillary absorbents that penetrate every part become inflamed and enlarged, and cease to discharge their functions; hence arise the enlargements of the substance of various parts, swellings of the legs, chest, and head; these are sudden, painful, and enormous, and are distinguished by a heat and tenderness which do not accompany other enlargements.

Symptoms in Man.—The symptoms of glanders in man, as in the horse, may be divided into constitutional and local. Soon after inoculation, the constitutional symptoms commence with febrile excitement, loss of sleep, and impairment of appetite; the patient suffers from chilly sensations, alternating with flushes of heat; the articulations feel stiff and sore; the back and limbs ache; and swellings frequently appear in the groin, axilla, and neck. The fever soon takes on a more inflammatory character; rigors ensue; diarrhœa often occurs; and a decidedly typhoid condition is established. The pulse becomes quick and tumultuous (108 to 120 beats in the minute); the temperature rises to 102° or 104° Fahr.; the tongue becomes brown and dry; and delirium sets in. Accompanying these symptoms are inflammation of the mucous membrane of the nose, with pain in the region of the frontal sinuses and soreness in the throat and larynx; the nose and the whole face become hot, tumid, and purple; the discharge from the nostrils is sanguineo-purulent, copious, acrid, and excessively offensive.

In five or ten days, the second stage, or that of eruption, begins, and the specific character of the disease is at once developed; when the eruption is delayed for some weeks, the disease is said to be in a chronic form. The

eruption of glanders is hard and pustular, and resembles that of smallpox. Virchow thus describess the development of the eruption.

There appear at first some reddish spots, which are very small, and resemble flea-bites, and which soon acquire a papular elevation, ultimately rising above the level of the surface like small shot, and assuming a yellow color. These shot-like knots are either flat or round, they do not lie in a bladder-like elevation of the epidermis, but in a kind of hole in the corium, as if this had been punched out; they are not always solitary, but often arranged in groups. The parts around are somewhat injected, and under the epidermis there is found a seemingly consistent puriform and yellow fluid, which is chiefly formed from softening of the knots. These are composed of a homogeneous yellowish substance, which is pretty firm and somewhat brittle, and which has great resemblance to tubercle. Microscopically examined, the knots present an amorphous granular appearance, and are mixed with cell elements and cell growths, and with numerous fat globules.

The tubercles may be developed in the subcutaneous tissue, producing hard and painful swellings, which are oval and well defined. These break down and give rise to excessive sloughing of the parts. The tubercles often appear throughout the mucous membrane of the respiratory apparatus. The kidneys, the pancreas, the testicles, and the liver may be similarly affected in the latter stage of the disease. In the acute form, the disease is usually fatal in a few days, but in the *chronic* form, it may last for weeks and even months. Mr. Travers gives the history of a case which, at the end of two years and six months, was still running its course.

The acute form of glanders may be accompanied with acute farcy, in which there is generally diffused suppuration in the entire limb. In chronic farcy, the tubercles often degenerate into foul ulcers, and sometimes terminate in an attack of acute glanders.

Diagnosis of Glanders.—In regard to the diagnosis, the early general symptoms do not differ from those of other forms of animal poisoning, while in the early period the eruption has the shotty feel of smallpox; but the history of the case will almost always point to the true nature of the attack, it being generally found, on inquiry, that the patient has handled a glandered horse, or nursed another person affected with the disease.

Prognosis.—The prognosis in this disease is always grave. The acute form nearly always ends fatally, fifteen cases collected by Rayer having given only one recovery. The chronic form of the disease is, however, not so fatal, ten cases referred to by Rayer having given seven recoveries and but three deaths. Youatt declares that glanders does not now produce one-tenth part of the ravages among horses that it caused thirty or forty years ago, and that generally speaking the disease is at present only met with as a common affection where neglect, filth, and want of ventilation are found.

Treatment of Glanders.—In the treatment of this disease, supporting measures must be employed: Quinine, tincture of the chloride of iron, and brandy, are among the most useful remedies; morphia should be used to control the pain.

The patient's apartments should be constantly well ventilated, and the utmost attention paid to cleanliness; abscesses should be promptly evacuated, and the parts washed out with a weak solution of chloral or of carbolic acid, and then wrapped up with cloths saturated with one or the other of these fluids.

Malignant Pustule.

Malignant pustule is a general disease which originates from contact with the blood or tissues of diseased animals, such as sheep or horned cattle, which are affected with *murrain*. It primarily affects the skin and connective tissue, appearing in the form of a vesicle, and rapidly developing gangrene. The disease at times appears as an epidemic with a very destructive tendency, and, as the virus is readily conveyed to horses, mules, and hogs, immense numbers of these animals are swept off by its ravages. The virus is readily conveyed to man, and the true test of malignant pustule is found in the fact that it is capable of being conveyed by inoculation from the human being to the sheep. When the virus from a suspected case of the disease is inoculated in this animal without effect, it may be assumed that the affection is not malignant pustule.

From the nature of their vocation, herdsmen, butchers, tanners, and other persons who work among hides, and who skin and eviscerate the bodies of animals, are liable to inoculation; the virus is also capable of being conveyed by flies and insects from diseased animals to man. The hands and face are the parts usually attacked, being most exposed. Stone, of Massachusetts, reported in 1868 seven cases which occurred to persons working in curled hair, and Bourgeois relates the case of a workman supposed to have been inoculated while picking the hair taken from an old sofa. Prof. Gross speaks of three cases which occurred in persons who had contracted the disease while picking and eviscerating buzzards for the purpose of extracting oil from those birds.

The hands and forearms of each individual were inoculated, and violent local and constitutional symptoms appeared at the end of two days. The parts became excessively swollen and painful, and covered with numerous vesicles, which, when ruptured, exposed ill-looking ulcers, which continued to discharge a thin, sanious fluid, and remained open for many weeks. The inflammation reached the axilla, and some of the glands of that region became enormously enlarged, and finally suppurated. Prof. Gross adds that recovery took place only after a long time, and after great suffering, which reduced the patient to the utmost degree of exhaustion. It could not be determined whether the poison was actually generated by these birds, or merely conveyed by them through their feathers being charged with carrion.

Symptoms of Malignant Pustule.—Malignant pustule begins as a red spot followed by a vesicle, which soon becomes pustular, and of which the characteristics are the extreme smallness of its dimensions, its being surrounded by a vascular areola of leathery hardness, its constant itching, and its extreme sensibility. The vesicle soon becomes enlarged, and is filled with a thin turbid serum; when it becomes pustular, it assumes a yellowish-brown color, and, increasing in size, soon bursts, and exhibits a foul gangrenous ulcer, which discharges a fetid excoriating fluid. While the vesicle is undergoing these changes, the parts become greatly distended with serum and lymph, very heavy, numb, and painful. If situated on the hand, the whole extremity becomes inflamed as far as the shoulder, and the axillary glands become involved. The number of vesicles may vary. In one of the cases observed by Prof. Gross, there was only one; in another there were two, one on the hand and one on the forearm; in another they were so numerous that the whole arm and hand were literally covered with them. When the disease appears on the face, the whole countenance becomes dark and greatly distorted; the eyelids generally are closed, thick, and difficult to move, and the disease fre-

quently extends to the throat, rendering respiration and deglutition very difficult and painful.

The *constitutional symptoms* which accompany these local manifestations are well pronounced: these are general uneasiness and anxiety, and afterwards high fever accompanied by rigors; a typhoid state soon follows, and septic infection then becomes manifest, from which condition, as a general rule, few patients recover. The disease is more dangerous when the pustule is located on the face than when it is on the arm or hand. It frequently runs its course in less than a week from the time of inoculation, and after death rapid decomposition is apt to ensue.

Pathology of Malignant Pustule.—Davaine considers the co-operation of specific organisms as proven in malignant pustule, and the investigations of Hodges, of Boston, and of late those of Dr. Robert Koch,[1] appear to corroborate this view. [Dr. Gerald Yeo considers the disease identical with that known as *Mycosis Intestinalis*, and believes that the presence of an external pustule is not an essential part of the affection.]

Treatment of Malignant Pustule.—The treatment of this disease is local and constitutional. With regard to the *local* treatment, the pustule should be destroyed as soon and as thoroughly as possible, wherever may be its situation, or whatever its stage of development. The best way to accomplish this, according to Dr. Devers, is by the application of the actual cautery at a white heat. This author asserts that the white-hot cautery has the advantage of destroying only the part which it touches, and that it promotes the effusion of a large quantity of serum, and induces the necessary reaction in the adjacent parts better than any other means which can be employed. He adds that if the epidermis is elevated by recently exuded serum, and separates itself around the necrosed part, the cauterization has not been sufficiently deep, and must be repeated. Mauserzin[2] recommends the extirpation of the pustule by the knife, and the subsequent application of the hot iron to the surface of the wound. Complete excision is also recommended by Prof. Gross. After excision and cauterization, the parts should be enveloped in a warm emollient cataplasm, and the patient kept at rest, and supported with nourishing diet.

The *constitutional* treatment, when the system becomes infected, consists in maintaining a constant supply of fresh air in the patient's apartment, and in endeavoring to maintain his strength by the administration of strong animal broths, and milk with brandy, while pain is allayed by means of opiates. [Quinia and the mineral acids may also be given with advantage. Iodine both internally and externally is recommended by Cézard, and carbolic acid by Estradère.]

[1] On Traumatic Infective Diseases. Translated by W. Watson Cheyne, F.R.C.S. London, New Sydenham Society, 1880.

[2] Archives Générales de Médecine, Mars, 1864.

SCROFULA AND TUBERCLE.

BY

HENRY TRENTHAM BUTLIN, F.R.C.S.,

ASSISTANT SURGEON TO, AND DEMONSTRATOR OF SURGERY AT, ST. BARTHOLOMEW'S HOSPITAL, LONDON.

TUBERCLE.

SCARCELY any task in medicine is now more difficult than that of writing clearly on Scrofula and Tubercle. The nature of both diseases, the structure of their morbid products, their relations, are all matters of uncertainty which modern pathology and the microscope have not yet succeeded in rendering plain. Indeed the confusion which prevails is almost greater than that of twenty years ago, in spite of the excessive labor which has in many countries been devoted, especially to the subject of tuberculosis. Nor can we yet be certain whether this confusion may not endure; or whether out of it we may expect to see order and perspicuity established. We cannot even define either disease with accuracy. For there is a total lack of unanimity of opinion respecting some of the foundations on which an account of scrofula and tubercle should be based. We still hope, however, that from the shadowy lines which now exist, some master-hand may form a sketch, perfect in all its parts, firm and clear in outline, correct in its proportions, and delicately toned in light and shade. Until this has haply been accomplished, the only course which remains to each successive writer is to sum up, as it were, on the evidence which is laid before him, and to present to his readers an account, as clear as he is able, of each subject.

I shall depart from the order usually observed, and shall treat first of TUBERCLE; and as I am not able to define tuberculosis, and scarcely know how to describe it in accordance with all the most recent doctrines, I am almost compelled to adopt a course which for other reasons I prefer:—first, to relate certain cases which will, I believe, be regarded by almost all authors as cases of tubercle, and then to deduce from them an account of the disease.

CASE I.—A girl 15 years old, was admitted into St. Bartholomew's Hospital in July of the present year (1880). Occupying the submaxillary region of the left side, and extending across the middle line, was a greatly enlarged lymphatic gland, measuring about two and a quarter inches in length by half an inch in breadth, and as thick as it was broad. It was smooth, of oval shape, firm but elastic, and could be moved with tolerable freedom. Several of the glands in close proximity to this one were enlarged, but to a far less degree. The child was pale-faced, with gray eyes and fair hair; her skin not very thin, nor freckled; her eyelashes not long; her superficial veins not large or prominent. Her mother told us that the tumor had existed in the girl's neck for fully six years, that no cause of its origin had been recognized, and that from the onset it had very slowly continued to increase in size. It had never been

painful, nor inflamed. There was no history of tubercle in the family; and, with the exception of the tumor in her neck, the child had always enjoyed good health. The large gland and one or two of those which lay nearest to it were removed, and the wound healed as kindly as could be desired.

No tubercles could be distinguished in the excised growths by the naked eye. They presented the appearance merely of hypertrophied lymphatic glands. Each was inclosed in a thin capsule. The consistence of each was a little less firm than that of a normal gland; the color a little less dark. The surface of a section was finely granular, or homogeneous, not traversed by fibrous bands; and nowhere was there pus or caseous material, or obvious degenerative change. Had it not been for Oskar Schüppel's[1] treatise, it could scarcely have been suspected that these glands were tuberculous. But the microscope discovered in every section numerous bodies of round or oval shape, each consisting of a central giant-cell surrounded by lymphoid and epithelioid cells, inclosed in a delicate reticulum, and the whole body often surrounded by a kind of fibrous capsule. These tiny bodies lay sometimes close together, but more often separated by lymphatic tissue. In no one of them could vessels be distinguished. Their microscopical characters corresponded so closely with those ascribed to tubercle, that the glands were regarded as tuberculous; but in the future consideration of this case, it must be borne in mind that the diagnosis rested solely on the microscopical examination.

Case II.—F. S.——, a young man, tall and thin, with brown hair and blue eyes, and with full-colored cheeks, was without any sign of general ill-health except a slight debility, apparently due to a restricted diet and rapid growth, for he was six feet high and had scarcely yet attained his majority. At the beginning of May, 1880, after jumping down from a height, he noticed that his left testis was enlarged and very slightly painful. It rapidly increased in size, but the pain subsided. He had never suffered from venereal disease. His father and his father's brother were said to have died of consumption. The left testis formed a smooth, oval tumor, about four inches long, bulging somewhat at both ends, but presenting no indication of a furrow between the epididymis and body of the organ, which parts seemed blended or fused together. The tumor was free from pain or tenderness. The scrotum was not reddened, but was a little puckered and adherent at the upper part. The cord was slightly thickened, but no enlargement of the glands could be distinguished.

On the 16th of June, the tumor was removed. The tunica vaginalis was everywhere adherent; the epididymis was hardly distinguishable until a section was made, when it was discovered to be but little altered, save that the globus major contained a mass of caseous material. Almost the whole tumor was caseous, but moist and firm, not friable. Towards the front was a little juicy material of a pale gray tint, which had not yet degenerated. No nodules or rounded bodies were visible to the naked eye. But microscopical examination revealed the presence of many bodies resembling those found in the glands in the last case. The giant-cell, surrounded by smaller cells in a delicate reticulum, was easily discernible, but the smaller cells were rather lymphoid than epithelioid, and very few of the tubercles were inclosed within a layer of fibrous tissue. There was a similar absence of vessels in the tubercles. The caseous material no longer formed a continuous and homogeneous mass, but was for the most part broken up into rounded bodies, often of small size and close together. From the microscopical examination chiefly, but also from the general appearance of the testis, the diagnosis of tubercle was made.

Case III.—A young gas fitter, aged 19 years, was admitted into the hospital in May, 1879. His mouth had been sore for about two years, but during the last three months his tongue had become ulcerated. Six weeks before admission an abscess had formed upon his face. His health had always been indifferent, but there was no family history of tubercular disease. While he was in the hospital, his cousin was an inmate of the same ward, convalescent from empyema, and suffering from chronic inflammation of the carpus. The patient was an ill-nourished, anæmic youth, with dark hair and eyes,

[1] Untersuchungen über Lymph-drüsen: Tuberculose. Tübingen, 1871.

and a sallow complexion. But his lashes were not long, his bones were small, and his temperament was only dulled by the severity of the disease. The middle of the dorsum of his tongue was occupied by an extensive ulcer of irregular shape, not deep except in front, where it formed a long fissure or deep cleft; its surface was pale and smooth; its border slightly raised, not undermined; and no induration was present, of either the border or the base. There were several superficial ulcers of the hard palate, and the cervical glands were, many of them, enlarged. During the following two months the ulcer continued, at first slowly, then rapidly, to enlarge, and its surface became foul and sloughy. The patient became more and more emaciated, and, quickly sinking, died at length on July 23, 1879.

On *post-mortem* examination, it was found that in addition to the ulceration of the tongue and palate, and the affection of the glands, the soft palate was swollen, ulcerated, and eaten out by numerous cavities containing caseous matter. The epiglottis was ulcerated, and thence the ulceration extended along the aryteno-epiglottidean folds and down the larynx to the true vocal cords, at which point it was arrested. The upper part of the right lung was adherent, and hollowed out by cavities many of which were filled with blood. In the tissues of the lung, around these cavities, were numerous bodies of small size and gray or yellow color, or gray with a yellow centre. In the left lung existed collections of caseous matter varying in size. The other organs of the body were normal. The diagnosis of tubercle in this case rested upon the characters of the ulceration in the mouth, and upon the enlargement of the lymphatic glands: it was confirmed by the presence of cavities in the lung, and of typical tubercles around these cavities.

CASE IV.—This series of cases may be well concluded by that of T. S., a farm laborer, 46 years old, who came to St. Bartholomew's Hospital in March, 1877, complaining of certain symptoms of stone by which he had been distressed for upwards of a year. During that period he had experienced constant difficulty and pain in micturition, and had often passed water mixed with blood. His symptoms had increased in severity during the last two months, and the urine had become turbid; and for three weeks before admission his testes had grown larger, and had been painful. Previous to this illness the patient had always enjoyed good health. No member of his family had suffered from consumption. He was a strong-looking countryman who preserved the appearance of health in spite of the distress occasioned by his disease. He suffered continual pain over the region of the bladder; was obliged to pass water at least every half-hour, by day and night, and each attempt at micturition was attended by straining and severe pain. His urethra was exquisitely sensitive, so that he could scarcely bear the passage of an instrument, however gently introduced. But there was no stricture, and no stone. Each testis was enlarged, and the epididymis especially was hard and nodular. His symptoms rapidly became more urgent, and to the rest were added others indicative of cerebral disease.

On the 13th of April he died, as it appeared, from inflammation of the brain or of its membranes. But no inflammation was discovered after death, nor were any tubercles observed on the membranes of the brain. Indeed, to all outward appearance the contents of the skull were normal. The bladder wall was thickened, the mucous membrane generally inflamed and ulcerated. The right ureter was dilated, and its mucous membrane inflamed; and the inflammation extended into the dilated pelvis of the kidney, the secreting substance of which contained large caseous masses. The pelvis and calyces of the left kidney were widely dilated, and scarcely any of its secreting structure still remained. The epididymis of each side contained caseous masses, and in the body of each testis were numerous gray and semi-translucent bodies, from the size of a millet-seed to that of a pea. The liver, spleen, and lungs contained large numbers of bodies bearing similar characters, but in the lungs many of these bodies were of large size and yellow, and softening in the centre. Examined with the microscope, the smallest bodies generally contained a giant-cell, and around it lymphoid tissue or larger epithelioid cells in a delicate reticulum. In the larger bodies the giant cell was replaced by granular débris, which often extended far beyond the area which might formerly have been occupied by the giant-cell. No vessels could be distinguished in any of these bodies.

Analysis of the above Cases.—Since each one of these cases would be described by some noted pathologists as a case of tubercle, I shall venture to regard all of them as tuberculous, and to use them for the purpose of analysis. But if they be compared together, it will at once be seen that they do not accord in many of their prominent features. For example, the duration of the disease was in one case twelve years, and the patient is still alive and well; while in another case it was scarcely more than a year before it proved fatal. The lesions were in the first case limited (during many years at least) to the lymphatic glands, and even to a certain group of glands; in the third case they extended over a wide area of the respiratory tract, while in the last case they were distributed over many organs and tissues. The general appearances of the lesions differed conspicuously, for the disease of the lymphatic gland in Case I. bore the characters of simple hypertrophy; that of the testis in Case II., those of inflammation with general caseous degeneration; and that of the affected organs in Cases III. and IV., the characters commonly described as tuberculous. The patients themselves presented no common points of resemblance, in feature, in color of hair and eyes, in complexion, or in general configuration, while their ages varied from 15 to 52 years. Clinically, there appear then to be no characters which are common to them all; no characters which we can describe as pathognomonic of tuberculous disease. But, pathologically, we discover in every case, in some of the organs or tissues, small bodies, generally of spherical or spheroidal shape, but apt to lose their shape as they increase in size or become confluent. The larger of these bodies are plainly discernible with the naked eye; indeed some of them are as large as peas or even larger. The smallest can only be discerned with the aid of low powers of the microscope, when they present a similar rounded or spheroidal shape.

Morbid Anatomy of Tubercle.—Here then we seem to be in possession of the key to all tuberculous affections—the presence in the affected tissues of small bodies of rounded or spheroidal shape, which we call tubercles. But in truth, at this point the first difficulties arise, and the earliest departure from apparent uniformity occurs. It is impossible to rest content with a definition of tubercle so loose as this. We must dissect tubercle, must analyze it with the microscope and describe its minute structure with accuracy. We must know, too, in what tissues it is found; what is its nature; what are the causes which tend to produce it; and the conditions in which it occurs. On all these questions there exists diversity of opinion; on some of them a diversity of opinion so considerable, that it seems now as if the conflicting views could never be reconciled.

Take, for example, the question of the minute structure of tubercle. Sometimes it appears to consist solely of retiform tissue—of leucocytes, or cells resembling leucocytes, in the meshes of a delicate reticulum. Such, according to Ziegler,[1] is the structure of those bodies which, with marked constitutional symptoms, attack almost simultaneously many tissues and organs. Sometimes tubercle is composed of endothelial elements, while some tubercles again consist of both these forms of cells. In the centre of some tubercles, a giant-cell is found, irregular in shape, furnished with many nuclei, and by certain pathologists regarded as an essential element of tubercle. Even the grouping of the nuclei, when they leave the centre free and approach the circumference of the cell, is thought to be characteristic of the giant-cell of tubercle. Some tubercles are caseous; others are composed in part of fibrous

[1] Ueber Tuberculose und Schwindsucht. Sammlung klinischer Vorträge (Volkmann's), No. 151, 1878.

tissue. As with the elements of which tubercles are composed, so with the manner of their combination, there is an absence of uniformity; nay, I might almost say, what appears to be almost an absence of design, save that we can often distinguish a relation between tubercles of a certain structure, and the tissues in the midst of which they lie.

There is indeed one feature in the structure of these bodies which, I believe, is admitted by all observers, the absence, namely, of vessels in their interior. Whether a tubercle be large or small, whether it be degenerate or organized, whether it be formed of endothelium or of leucocytes, in every instance it is absolutely non-vascular.

Origin and Natural History of Tubercle.—As long as uncertainty prevails on the fundamental proposition of what is a tubercle, it seems idle to discuss its origin and natural history. Yet no paper on the subject would be complete which did not discuss these points, and the only question is how they can be considered here with most advantage. Perhaps by making an arbitrary definition of a tubercle, and using the definition thus formed as a basis on which to build a history of the disease. We need not, however, make a purely arbitrary definition, but may assume that the word tubercle, employed most exactly, signifies what is perhaps the commonest form of the disease—those tiny bodies which often cannot be distinguished with the naked eye, but which are discovered by the microscope to consist of a central giant-cell surrounded by lymphoid and epithelioid (or endothelioid) cells, contained in the meshes of a delicate reticulum. No vessels are present within them. These bodies may be found within the coats of small vessels (as in the pia mater), or in the various connective tissues. Indeed, with the exception of cartilage, of the connective tissue of the external musculature, and of the coats of the large vessels, in which they have not yet been discovered (Fränkel),[1] tubercles may occur in every part of the body. They are found, too, commonly in connection with endothelium, growing for example about the trabeculæ of the omentum; but apparently they do not grow in the midst of epithelium.

As with the situation, so with the origin of tubercles. They may arise from the coats of the smaller vessels, from connective tissues, and from endothelium; but not from epithelium, although Cornil and Ranvier[2] have expressed a contrary opinion. They may originate too from colorless blood corpuscles or wandering cells, as the glass disks of Ziegler proved. Ziegler's disks indeed proved more than this, for they showed that there was nothing specific either in the elements of the tubercle which we have described, or in the combination of those elements. For the body formed between these disks corresponded in all its characters with tubercle. Tubercles, once formed, may remain unchanged for a considerable time; or they may enlarge, and still for a time retain their form and structure; but more often they become transformed. Sometimes the transformation is degenerative or destructive; the central portion slowly becomes caseous, or dies, probably from insufficient nourishment incidental to the crowding of its cells, and to the absence of vessels within it; the caseation may spread until the whole tubercle is involved, and wide areas of caseation may be produced by the degeneration of many tubercles in close proximity, and of the intervening tissues. Sometimes the transformation is towards organization; fibrous tissue is developed; indeed it is not uncommon to find tubercles of the smallest size surrounded by a kind of fibrous covering.

[1] Tuberculose; Handbuch der Kinderkrankheiten (C. Gerhardt). Bd. 3. S. 153. Tübingen, 1878.

[2] Manuel d'Histologie pathologique, p. 199. Paris, 1869.

Once formed, tubercles are not prone to disappear or to be resolved, although Lebert[1] states emphatically that tuberculosis at all ages, in all situations, and in all places of its development, is capable of cure. Far more commonly they are associated with inflammatory changes, the tendency of which is throughout destructive. Suppuration in and about lymphatic glands; disintegration and protrusion of the testis through an opening in the scrotum; ulceration of mucous surfaces and of the skin; these are the conditions of which tubercles are too often the precursors. These conditions are probably all more or less closely connected with the caseation or molecular disintegration to which tubercles are so frequently subject.

Infection of Tubercle.—But there is another cause, more potent than even these, which tends to hinder or prevent the cure of tubercle, or, to speak more justly, of tuberculosis. A tubercle once formed seems to possess the power of generating its kind. A tuberculous tissue or organ is not only a source of danger in itself, but a source whence new tubercles may be acquired. The spread of the disease is not always in the same direction, or to the same extent. Sometimes it remains limited to a single organ, which may be completely filled with tubercles. An example of this may be found in the testis of the patient in Case II., in which, however, it must not too hastily be assumed that the condition was due to the spread of the disease, for there is no distinct evidence to show that all the tubercles may not have been formed at the same moment. Sometimes tubercle invades a group of organs, spreading slowly from the first affected to the others. Such an extension of tuberculous disease may fairly be supposed to have occurred in Case I., where one lymphatic gland had been diseased for many years, and subsequently each gland of the whole chain of *glandulæ concatenatæ* had become enlarged, and (if we may judge by the examination of the smaller gland removed) probably tuberculous.

The infective material may probably be conveyed by various channels. It may be carried by the small arteries from near the root or hilum of an organ to its deeper parts. Or it may pass through the lymphatics to the neighboring lymphatic glands, a method of extension so frequent that primary tuberculosis of certain parts, the tongue and pharynx for example, is invariably associated (provided that the primary disease has been of sufficiently long duration) with tuberculous affection of the neighboring glands. Or it may travel through the veins, and reach the lungs from distant parts, and from the lungs again be disseminated through the body. Examples of this are numerous, but it will be sufficient to cite Case IV., in which the primary disease was, it may be believed, of the urinary mucous membrane, and in which, shortly before the patient's death, the lungs, the liver, and the spleen became diseased. Or, lastly, and this is one of the most common methods of extension, the disease may spread over the surface of a membrane first attacked, or the infective material be carried to distant parts of long tracts of membrane, and there produce new tubercles. Illustrations of these conditions may be found in Cases III. and IV. In the former, the affection spread, as if by continuity, along the surface of the tongue to the pharynx and the larynx, and thence probably was conveyed by the air-passages, but without infecting them, to the lungs. In the latter, the disease attacked the genito-urinary tract, and, while it spread over the surface of the bladder, and through the substance of the kidneys and the testes, and was perhaps conveyed from one of these organs to the others, there were still wide tracts of normal or nearly normal intervening membrane.

[1] Traité clinique et pratique de la phthisie pulmonaire, etc. Paris, 1879.

Nature of Tubercle.—The uncertainty which prevailed regarding the nature of tubercle, and the resemblance of some of its processes to those of the malignant tumors, led Virchow,[1] many years ago, to regard it as a malignant tumor-formation. Its structure, apparent incurability, and the manner of its extension, were the chief among the conditions which led Virchow to adopt this view. Certainly it is an attractive theory, and may yet, perhaps, be proved to be correct for some of the bodies which are included under the name tubercle. But against its universal application, several arguments may be advanced. First, the almost constant association of the disease with inflammation—an association so constant that tubercle is regarded by most authors as the product of inflammatory changes. Next, the absence of vessels within the tubercle, and the wondrous frequency of caseation, are both unlike the characters of a malignant growth. Caseation does indeed often occur in carcinoma and sarcoma, but not as if it were an almost necessary transformation of their tissues, or so largely as to produce great masses of caseous material. There are some peculiarities, too, in the manner of infection of the primary disease, in which tubercle differs from the malignant new-formations; in the manner, for example, in which it is often scattered over wide tracts of membrane. And lastly, we can do with tubercle what we have not yet succeeded in effecting with any of the malignant growths: we can produce it at will.

Not in the human subject, but in certain of the lower animals, a body closely resembling tubercle in its essential attributes, may be produced by the introduction of certain substances within the body of the animal. This artificial tuberculosis may be produced most readily in the guinea-pig and dog. If we insert beneath the integument of either of these animals, a small portion of degenerated (caseous) tubercle, the animal falls sick and dies within a few weeks. Section discovers tuberculous inflammation of various organs, notably of the lungs. Or if we inject into the pleural cavity a fluid containing caseous particles from a tuberculous lymphatic gland, the infective material first spreads itself over the surface of the serous membrane, producing at numerous points nodules of induration (tubercles); thence is conveyed along the lymphatic channels to the nearest glands, in which similar nodules are produced; and by the veins is disseminated through the body. The indurated nodules thus produced consist for the most part of masses of adenoid tissue, and do not exhibit the structure of the typical tubercle from which we started, although in the lungs epithelioid cells enter largely into their composition. These artificial tubercles, too, are subject to much more rapid and extensive caseation than are the tubercles of acute human tuberculosis. And, lastly, it is singular that, in the artificial tuberculosis of animals, the brain, so often the seat of the disease in man, is never attacked.

These are the chief differences between the natural and the artificial, acute tuberculosis; but they are not sufficient to counterbalance the evidence in favor of the view that the artificially produced disease is in truth tuberculosis. The story of the induction of tuberculosis does not, however, end here. The experiments of Sanderson and Fox[2] have made it clear that a mere injury inflicted in a certain manner, may produce tubercle as surely as the inoculation or injection of degenerated tubercle. For if a seton be introduced into a guinea-pig or dog, or non-tuberculous material be inserted, each of these injuries is equally followed by the formation, locally, of a cold abscess, and, later, by tubercles similarly distributed to those which follow the employment of a tuberculous agent. Moreover, it has been found that only certain animals

[1] Krankhaften Geschwülste, Vorles. xxi.
[2] Recent Researches on Artificial Tuberculosis. Edinburgh, 1869.

can be rendered thus with ease tuberculous, while others—the cat, for instance—resist the infection, and escape unharmed. The lessons taught by these experiments are, that tubercle may be artificially induced; that any lesion which will produce a cold abscess, or, better still, caseation, may be the agent by which tuberculosis may be induced; that there is nothing specific, therefore, in the infective material; but that, since certain animals are easily infected, while other animals as easily resist the infection, a certain predisposition to tubercle is probably essential. The characters of artificial tuberculosis lend great weight to the theory of the inflammatory nature of the disease, for all its processes are apparently closely associated with inflammation.

The bearing which these experiments have on human tuberculosis can scarcely be over-estimated, and yet it may be very differently rendered. If tubercle can be produced in animals by the introduction into them of caseous material, whether tuberculous or not, why should not tubercle in man be in some such manner also closely connected with the presence of caseous matter in his body? Long before the institution of these experiments on animals, Buhl[1] had noticed the exceeding frequency with which caseous masses occurred in subjects who were tuberculous, and had been led on this, and other accounts, to regard tubercle as the product of infection. He came, indeed, to regard all tubercle, whether acute or chronic, whether general or local, as due to the absorption of infective material from caseous centres. Now, although this view cannot be maintained in the complete form in which it was advocated by Buhl, it is, nevertheless, with some slight modification, the view most commonly adopted at the present day. The infective or absorption theory of tubercle assumes that all tubercle is produced by the absorption of infective matter, but not necessarily of caseous matter, although caseous matter is one of the most powerful infective agents. But there are certain difficulties which prevent it from being universally accepted. For example, the centre of infection cannot always be discovered, even by the most careful seeking—a difficulty which may be explained by assuming that it has disappeared, either by absorption, or, it may be, by suppuration. Again, if caseous matter be so powerful an infecting agent, how can those cases be explained—and they are not few—in which caseous masses exist, or have existed, in the body for a lengthened period, and yet in which no tubercle is produced?

In reply to this question, it is suggested that a certain predisposition or tendency to the formation of tubercle is necessary, and, as an illustration of this law, the marked difference which exists between certain groups of animals in their relation to tubercle is cited—an illustration which, by the way, loses something of its point from the fact that the law, which in animals is applied to whole races or species, is in man applied only to individuals. And as the insufficiency of this answer has been plainly felt, it has further been suggested by Niemeyer,[2] that the masses of caseous matter, to infect, must be in a certain stage or condition, and must not be surrounded by a capsule; and yet one more reason is assigned for the infecting capabilities of certain caseous masses, for the infectious nature of certain sputa—that they contain micro-organisms—according to Klebs,[3] a form of coccus (the Monas tuberculosum), according to Buhl,[4] bacteria.

Pathology of Tubercle.—These, then, are among the problems which now perplex pathologists in the nature and processes of tubercle. If we are compelled to hold fixed views on any of them, those which suggest themselves as

[1] Lungenentzündung, Tuberkulose und Schwindsucht.
[2] Text-book of Practical Medicine, translated by Humphreys and Hackley.
[3] Handbuch der pathologischen Anatomie. [4] Op. cit.

most acceptable and worthy of credence are that tubercle, in its most perfect form, possesses such a microscopic structure as that which we described in defining it; that some tubercles never attain this complete or typical structure, while others either degenerate or become further developed; that deviations from this type may and do occur, in accordance with the situation in which a tubercle is found; that tubercle is an inflammatory production, not a malignant growth (as sarcoma and carcinoma are malignant); that a tuberculous tissue or organ is a centre whence tubercle may be conveyed throughout the body; that the channels by which the conveyance is effected are several; that tubercle may be produced in the bodies of certain individuals by the absorption of an infective material. But the evidence which is furnished on the more advanced questions is not yet sufficiently convincing to permit us to form a decided opinion on them. We cannot yet assign to each tubercle its value. We cannot be sure whether all tubercles are due to the absorption of infective material, or whether they sometimes own another cause. Nor can we say with certainty whether the infective material is simple, or whether it is specific. And although we may admit that a predisposition to tubercle is necessary ere it can be developed, we are not yet in a position to define the nature of this predisposition. A few years ago, inheritance was regarded as one of the chief predisposing causes of tuberculosis. Now, it is said that tuberculosis is not inherited, but that the offspring inherits from the parent a tendency to the production of caseous masses, from which tubercle may be developed.[1]

Treatment of Tubercle.—The tuberculous affections in which surgery is mainly interested, are those of which examples have been given; of the tongue, the pharynx, the glands, the urinary mucous membrane, and the testis. The bones or periosteum, and the synovial membranes, may be added to the list, while tubercle of the larynx and the choroid are more likely to be met with in the practice of the special surgeon, or the physician.

It is not intended that this article should comprise a detailed account of the tuberculous affections of each part. These will be treated of in subsequent pages devoted to the study of the special organs and tissues. It now only remains therefore to indicate the main lines on which the treatment of tuberculous disease is founded. Treatment is directed not only to the cure of those who are tuberculous, but to the prevention of tuberculosis. For our wider knowledge of the etiology of the disease, and of the course which it may not improbably pursue, leads us, not unnaturally, to adopt those measures which seem calculated best to avert its cause, and to arrest its progress. We believe that the offspring of tuberculous parents are predisposed to tubercle. We cannot prevent the parents from begetting children, but we can place many of the children in conditions which will diminish their liability to tubercle. By careful hygiene, by clothing and by food, we may lessen the number of the tuberculous among the children of the poor; while for the children of the more wealthy classes, in addition to these things, each should be advised, if possible, to select a calling which will not subject him to frequent or long-continued strain, or expose him to continued cold and wet. Residence, too, in places where the air is clear and dry, and the winter not too long or cold, should be strongly recommended. When tubercle is actually present, to these measures are generally added, often with the best result, the administration of certain drugs, the beneficial influence of which over the progress of tubercle has long been recognized. Cod-liver oil and syrup of the iodide of iron are exhibited with bark and alkalies, or acids, as

[1] Billroth; Pitha und Billroth's Handbuch der Chirurgie; Bd. I., Abth. 2, Hft. 1, S. 307.

may seem best to meet the requirements of each individual case. For we believe that tubercle, however rarely, is capable of cure; both because persons who have seemed to suffer from tuberculosis of the lungs, have recovered, and because ulcers of the mouth and pharynx which have borne the typical tuberculous aspect, have been watched as they slowly but completely healed.

But when a limited area which is easily accessible, is tuberculous, and there is no evidence that the disease affects more distant parts, it seems but reasonable, in appreciation of the infectious nature of the disease, to cut away the affected portion as if it were a malignant growth. Of late years this has been done with tolerable frequency. The testis has been thus treated, and so have tuberculous ulcers of the tongue, and tuberculous affections of the bones and joints. Of the propriety of all these operations, there can be no doubt, provided that they are undertaken in fitting cases and performed with all due care. But opinion is not so unanimous as to the advisability of removing lymphatic glands containing tubercles. For, although the disease may remain long limited to a certain group of glands, it is not often limited to a single gland, but quickly spreads from one to another. A whole group of glands can rarely be removed, especially as the cervical glands are those which tubercle most commonly affects. And if one, perhaps the largest, of a certain group be taken away, the operation so far from being beneficial may even prove the reverse by exciting to activity the morbid process in the glands still left behind. A case illustrating this is that of a girl twelve years old, who for two or more years had suffered from a tuberculous gland in the middle line, beneath the floor of the mouth. Sometimes it suppurated, and unhealthy ulcers formed; and, again, the openings closed and all bid fair for cure. But the lump remained, and was a constant eyesore and source of annoyance to the patient. I removed it, therefore, with all due care, and the wound healed by the first intention. Now, however, the neighboring glands, which before the operation had been quiescent and scarcely at all enlarged, quickly grew larger, and, suppurating, formed scars and ulcers, more distressing and disfiguring than the disease which I had removed. Further experience, based on numerous observations, is required to decide as to the propriety of operating under such circumstances.

Scrofula.

Two cases, shortly recounted, will serve to preface the description of Scrofula. Each of them is typical in its kind, yet it will be seen that the difference is great between them.

Case V.—The first is that of a boy, twelve years old, who came to my Out-Patient room nearly two years ago (February, 1879), with a swelling of the back of one hand. He was a well-grown lad, with fair hair, blue eyes, and a ruddy glow, as if of health. His skin was not very thin or freckled, nor was it so transparent as to permit the superficial veins to be seen clearly through it. The swelling of his hand had followed almost immediately upon a blow. It occupied the whole of the dorsum of the hand, but was most prominent over the third metacarpal bone, where the skin was reddened, hot, and tender. For many days or weeks it changed but little; then slowly suppurated; and at the bottom of the suppurating cavity bare bone was easily distinguished. After a while, almost the whole of the metacarpal bone was removed by operation, and there seemed to be no reason why the wound should not fill up by granulations and become a healthy scar. But the progress towards recovery was marvellously slow. The wound appeared to flag, and sinuses burrowed through to the palm; yet the general characters of good health were preserved, and no new local mischief in the bones or joints was discovered. At the end of a year of treatment, the hand was still unhealed. And now two ulcers

formed immediately above one elbow; of circular shape; with glazed or waxy surface, but discharging an abundance of thin pus; with edges of a dull red color, thin and widely undermined; and with congested integument around and between them, for they lay not far apart. A few weeks later, an abscess formed on the dorsal aspect of one foot, broke, and discharged a thin but curdy pus. Abscess, sinuses and ulcers, discharging all together, produced at length a sensible effect on the patient's health, in spite of good food, cod-liver oil, and preparations of iron and iodine. He was therefore sent for a while to the seaside, and when he returned, already benefited by the change, was taken on board his father's barge that he might enjoy the river air the whole day long. Slowly the discharge diminished and the wounds began to heal, and after several weeks some of them were really closed, and his general health improved. After which he ceased to attend the Hospital.

Case VI.—The second case occurred in a very different subject—a woman, whose age was only fifty-nine, but who was prematurely old. She was white-haired, anæmic, weak, and withered. The first phalanx of her left forefinger was greatly enlarged, and covered with thin, red skin, glazed and ulcerated. Sinuses passed directly into the interior of the bone, which was as if blown out into a thin-walled cavity, containing a soft material in which were numerous grits of bone. On the upper aspect of each foot was a circular ulcer, with thin, red, undermined edges, through which rough and carious bone could be reached. And over the left patella were two small ulcers, implicating the skin and subcutaneous tissue, but not connected with disease of bone. Her history was free from any record of specific disease. She had been always delicate, and about five years ago had become completely blind from amaurosis. Within the last two years, abscesses and ulcers had formed, first on the finger and then on the feet; and tiny fragments of bone had come away at intervals. She was kept under observation during several weeks, and was well fed and warmly clad. Quinine and iron were administered, and the wounds were dressed with a slightly stimulating ointment. But she made little or no progress towards recovery.

Nature of Scrofula.—To complete the account of scrofula by clinical illustrations would require many more cases than these, but these two patients presented certain common features of disease which are almost universally regarded as scrofulous. In both of them inflammation was set up by an exciting cause so trivial that only in one could it fairly be assigned. In each case the inflammation, thus excited, proceeded to suppuration; and ulcers were formed, the characters of which were for the most part of a certain definite type. The disease, once established, exhibited a disposition to maintain its hold; the affection of the bones slowly progressed to their partial or complete destruction; the ulcers, if they did not spread, certainly did not heal; and several regions of the body became the seat of similar disease.

In these few sentences, scrofula is almost defined, as far indeed as it appears capable of definition; for the essence of the disease lies rather in several tendencies or predispositions, than in any clearly defined conditions. In the two cases recorded, for example, there was nothing so characteristic in the signs or course of the inflammations, but that it might be imitated in the inflammations of those who are not suffering from scrofula. Nor were the ulcers such that they could be at once and certainly distinguished as scrofulous. Yet no one would, I imagine, be disposed to deny that these patients were suffering from scrofula. For scrofula may be described as a condition of the body, or of certain portions of the body, in which inflammations are easily excited; in which they tend towards suppuration and ulceration; and in which the power of spontaneous recovery is very feeble. It has been defined by Virchow[1] as consisting in "a greater vulnerability of parts and a greater pertinacity of disturbances," than is natural, and these expressions form the basis of the large majority of later and longer definitions.

[1] Krankhaften Geschwülste, Vorles. xxi.

Morbid Anatomy of Scrofula.—There is not in scrofula, as in tubercle, a pathological body, either microscopical or of larger size, peculiar to the disease. All the changes are those of inflammation, but the products of scrofulous inflammations may be analyzed, chemically and histologically, without the discovery of any substance or structure which may not equally occur in any or indeed in every inflammation. One thing certainly is noticed of the lymph produced in scrofulous inflammations; not only that it tends to suppurate, and is little prone to organization, but that it has a very strong tendency to degenerate into caseous material, by absorption of the fluid parts, and by withering and distortion of the cells. These, mixed together, form a yellow substance in which fatty molecules abound, and in which plates of cholesterine and the débris of tissues which have been disorganized are found. But caseation, although it is so common, is not a constant result of scrofulous inflammation. And even if it were so, it is a condition so frequently occurring in connection with other forms of inflammation, the tuberculous, for example, that it could not be regarded as in any way distinctive of scrofula. The abundance of lymphatic elements, too, which has been noticed by Fränkel[1] in scrofulous inflammations, is not more distinctive of them than is caseation.

Diagnosis of Scrofula.—Although scrofula is a disease thus difficult to define, and though its lesions are not separated by any well-marked limit from those which may result from other debilitating diseases, it is nevertheless not difficult to diagnose in such instances as the two which I have described. Even in less advanced cases, it may be recognized by certain characters presented in its lesions, which though they are not pathognomonic, are more uniformly observed in scrofulous affections than in any other. Let us leave for a moment the tissues and organs which are the seat of disease, and examine the characters of the lesions wherever they occur.

The inflammations are very slow in progress, lingering often for weeks before suppuration is established. Yet the signs by which they are accompanied are sometimes almost acute; the superficial redness is intense, the swelling considerable, the pain extreme, and even the heat is notably increased. All the signs predict an early suppuration and quick recovery. But the prediction is not fulfilled, for even the suppuration appears unaccountably delayed. Far more frequently, however, all the signs of inflammation are chronic throughout, and the abscess which results is cold or lymphatic. Yet even these abscesses often point, and break with superficial redness, and heat, and pain. The ulcers of scrofula are generally circular in form; with red or livid edges, not raised and scarcely thickened, but undermined sometimes over a wide area; with pale and flabby granulations, often large and flattened; and with an area of chronic congestion surrounding them. The discharge from these ulcers is generally abundant, but thin and watery. They remain apparently unchanged in size or characters for weeks, or even months, or, under unfavorable conditions, grow larger; and, where several of them lie not far apart, gradually approximate until they are only separated by thin, undermined bands or strips of red integument, or join to form larger sores with incurved borders. Even the scars which remain after healing, are characteristic of the disease. They are strangely puckered and distorted, often presenting prominent crests or ridges, and retaining the dull red or livid hue of the borders and surrounding areas of the ulcers. Occasionally the thin belts between the ulcers fail to become united with the subjacent healing surface, but, maintaining their vitality, heal separately and

[1] Handbuch der Kinderkrankheiten (C. Gerhardt), Bd. iii. S. 129. Tübingen, 1878.

remain as thin, elastic strips of skin, attached at each end and bridging over a slightly depressed, scarred surface. The disfigurement produced by these scars is often most distressing, especially when they occur, as they are apt to do, about the face and neck.

Tissues and Organs affected by Scrofula.—The affections due to scrofula are unfortunately very numerous. Eczema and lichen affect the *skin*—not always readily recognizable as scrofulous, unless associated with other lesions, but always obstinate and difficult to treat. Still more intractable and more destructive than these eruptions, but with a pathology less clear, is the lupus called scrofulous or tuberculous, which occurs so frequently about the *upper lip* and *nose*. Ulcers and abscesses, bearing the characters just now described, attack the skin and subcutaneous tissue; and chronic inflammation and suppuration, the lining membrane of the cavities and passages of the *nose* and *ear*—often with the permanent establishment of ozæna and otorrhœa. Inflammation affects the follicles of the *eyelids;* chronic and phlyctenular inflammations the *conjunctiva* and even the *cornea*, leading to irritable ulcers which too frequently result in scars injurious to the sight. The *tonsils* are often permanently large and prone to inflammation, and sometimes a deeper and more extensive ulceration occurs about the *fauces*, which can with difficulty, if indeed at all, be distinguished from tuberculous angina. The mucous membrane of the *larynx* and *trachea* is not uncommonly the seat of inflammation; and bronchitis and pneumonia attack the *lungs*. The *vaginal mucous membrane* of scrofulous girls is occasionally the seat of chronic congestion and discharge.

But of all structures, the *lymphatic glands* are perhaps most frequently affected by scrofulous inflammations. Those of the neck are so often thus inflamed, that chronic enlargement of them has come to be regarded as nearly the most important sign of scrofula. In some cases, but a few glands, those behind the ear and sterno-mastoid, for example, are enlarged, while in other instances the whole chain of glands on either side is implicated. The mere fact of enlargement of the lymphatic glands cannot, however, be regarded as a sign of scrofula, for (1) non-scrofulous inflammations are common, especially in the neck, where so many causes may exist to induce secondary affection of the glands; and (2) the cervical glands are those which are chiefly liable to non-inflammatory diseases, of which examples may be found in lymphadenoma and lymphosarcoma. To add to the difficulties of early diagnosis, the scrofulous inflammations of glands probably rarely or never arise spontaneously, but are always secondary to primary affections of a like kind to those which induce non-scrofulous inflammations; to carious teeth; to eruptions about the ears, and face, and head; to stomatitis, and to similar affections. The only features in which the scrofulous glands at first differ from those which are not scrofulous, are their indolency, and the absence of pain and of the more acute signs of inflammation. But in their later course, they deviate more and more widely from what may be regarded as the natural course of inflammation in a healthy subject. The primary cause upon which the inflammation depends, may disappear, but the enlargement of the gland endures; nay, other and neighboring glands become enlarged. And in one or other of them, the solid feel gives place to fluctuation, the skin reddens, and at length an abscess points and breaks. Suppuration may occur in the inflamed gland or in the surrounding tissues, excited apparently by the contiguity of inflamed structures. In either case, the typical ulcers of scrofula are frequently produced, and disfiguring scars may finally result. Or in place of ulcers, sinuses are formed, which lead directly into suppurating

cavities lined with caseous material; and, as long as any of this material remains, the sinuses continue to discharge.

The scrofulous maladies of *bones* and *joints*, if not so frequent as those of the lymphatic glands, are not much less so, and are among the most important of all scrofulous affections. The bones are very liable to subacute and chronic inflammation, affecting more often the periosteum than the substance of the bone, or attacking both the periosteum and the bone, and leading, in a large number of instances, to caries and necrosis. It is not uncommon to find several bones in the same subject thus carious, as in the older of the two patients whose cases have been related. The bones, too, are the parts of the joints in which scrofula frequently commences. The articular ends become enlarged, and are slightly hot and tender; the cancellous tissue is infiltrated with the products of inflammation; caseation ensues; the inflammation extends towards the joint; the cartilage ulcerates, or is stripped off; and the whole joint becomes inflamed. Instead of the bones, the synovial membrane is often the structure first attacked. It becomes thickened, though the fluid in the joint may not be much increased; the inflammation slowly extends to other structures; suppuration takes place, with the formation of sinuses; and the joint is at length destroyed. The "white swellings" of joints are in many instances scrofulous affections, in which the disease has had its origin in the articular extremities of the bones.

Relation of Scrofula to Tubercle.—Many of the affections thus described as scrofulous can only with difficulty be distinguished clinically from those associated with tubercle, and even when the diseased structures are examined after removal or death, the appearances presented by the two diseases are so similar that the diagnosis can be made only by microscopical investigation. This clinical difficulty has so long been recognized, that the custom has obtained of classing both diseases under the common term *strumous*, a custom objectionable solely because the word is not always employed in this clinical sense; and some confusion of terms has on this account resulted. The striking similarity between the lesions of scrofula and tubercle, has, not unnaturally, suggested that the two diseases are closely related. Indeed, some authors refuse to recognize even a pathological difference between them, and the fact that in the principal works on surgery and medicine they are almost invariably included in the same section or chapter, shows how largely the impression of their near relationship prevails. Yet it is not easy accurately to define the tie by which they are connected. It appears almost certain that tuberculous parents may beget children who are scrofulous, and probably tuberculous children may be derived from scrofulous parents. But since either disease may apparently be acquired without inheritance, under certain favoring conditions, it is difficult to prove that anything more is inherited than a weakly constitution, in which under certain conditions scrofula or tubercle is developed.

It has become the fashion, of late years, for those who distinguish between the two diseases to regard scrofula as an affection which disposes more than any other to tubercle,[1] not merely by the general weakness it induces, but on account of the frequency with which caseous material is produced. If in this theory it be implied that persons who have for years suffered from typical scrofula, frequently fall victims to typical tuberculosis, I must confess that I have not often observed the sequence. But a different method is employed to prove the relation. Rindfleisch,[2] for example, holds that the very large

[1] Fränkel, Birch-Hirschfeld, Rindfleisch, Billroth, etc.

[2] Ziemssen's Handbuch, Bd. v., Abth. 2, S. 149. Leipzig, 1874.

majority of tuberculous lymphatic glands are secondary, not to primary tuberculous affections of the parts whence the lymphatics traverse them in their course toward the main lymphatic trunks, but to primary scrofulous affections of these parts. The scrofulous inflammations tend in most cases to caseation, and from the caseous material thus produced infection of tubercle occurs (secondary tuberculosis). Only one fault can be found with this ingenious theory, but unfortunately it is a grave one: the diagnosis of the primary scrofulous affection rests upon too slender a base. Because caseation is a frequent result of scrofulous inflammation, it is assumed that the presence of caseous material is a proof that a disease is scrofulous—an argument in a circle which cannot be permitted. If there really exists a closer relation than that of similarity of morbid or pathological conditions, it must I think be admitted that we have not yet succeeded in defining it.

Modifications produced by Scrofula in other Diseases.—The affections significant of scrofula have been described, but the account of the effects of scrofula is only partially complete.

For (1) we may believe that all simple processes of disease may be modified by scrofula. The *epididymitis*, for example, which complicates gonorrhœa in a scrofulous subject, does not pursue the rapid course of an ordinary epididymitis, and disappear under treatment in a few days. It may set in with equal severity, and the acute symptoms may rapidly subside; but thickening and induration of the epididymis remain, with slight heat and tenderness; or the inflammation may extend to the body of the testis, and, in spite of treatment, suppuration, and even hernia testis, may take place. So, too, the primary affection, the *gonorrhœa*, instead of passing off as usual under appropriate treatment, subsides into a gleet most difficult to cure.

And (2) we know that the processes of certain specific diseases are largely influenced by scrofula. In no disease is this more marked, perhaps, than in *syphilis*, the secondary and tertiary manifestations of which are aggravated by scrofula in an extreme degree. As I write, the miserable condition of one unfortunate young man, the subject of both diseases, is present to my mind. First treated in the hospital for scrofula, one of the most characteristic features of which was a white swelling of one knee, he was so indiscreet, when only partially recovered, as to expose himself to the contagion of syphilis. When some three or four months later he was again an inmate of the hospital, he was suffering from secondary symptoms of the severest kind. The profuse eruptions on his face and body suppurated, superficial ulcers and large, foul scabs were formed, and frightful disfiguration was produced. Both eyes were attacked with iritis, which lasted long, and left them permanently injured. His tongue and fauces were extensively and deeply ulcerated. The glands in various regions of the body became permanently enlarged. And with these local lesions was associated much greater constitutional disturbance than is usual. And, as the scrofulous disposition appeared to render every manifestation of syphilis more grave, so the syphilis appeared to aggravate the scrofulous lesions; for the knee, which had previously exhibited signs of improvement so clear that the disease seemed nearly at an end, again became actively inflamed, and threatened suppuration. It has not yet been shown that there is any relation more intimate than this between syphilis and scrofula or tubercle.[1] The children of syphilitic parents are not more prone to these diseases than other children whose constitutions are habitually feeble. Nor does acquired syphilis increase the liability to scrofula and tubercle, unless by inducing serious exhaustion.

[1] Bumstead and Taylor; Venereal Diseases, 1879, p. 498.

Another disease sometimes influenced by scrofula is *gout*. To this Sir James Paget[1] thus refers in his Clinical Lectures and Essays: "It is not very rare to find gout mingled with scrofula. . . . . The real mingling of gout and scrofula is found in elderly persons. In these a gouty inflammation may drift into true scrofulous inflammation, and the risk, though it be not great, should always be kept in mind." And further: "I believe that we may hold cases such as these to be due, mainly, to the coincident inheritance of both gout and scrofula; and I may mention two other sets of cases which may be referred to the same unhappy lot in life. In the first, an acute attack of gout is followed, as any fever may be, by some evidence of scrofula. In the second, among the cases of what I have called senile scrofula, some occur in old persons whose tissues have degenerated in long-continued or almost constant gout."

Causes and Course of Scrofula.—Scrofula occurs chiefly at two periods of life; the limits of the first period extending from about the third to the fifteenth year, while the second period scarcely commences before the age of sixty. But though it is most common in childhood and old age, no time of life is free from its occurrence. It attacks persons in every rank of life, sparing neither male nor female, rich nor poor; but the children of the poor are so much more liable to scrofula than the children of the rich or comfortable classes, that poverty is justly regarded as, at least, a predisposing cause of scrofula, on account of the indifferent and insufficient food, the foul and heavy air, the scanty clothing, constant exposure to wet and cold, and the hundred other evils with which it is associated. But the most powerful cause of scrofula is universally admitted to be inheritance, the inheritance of a predisposition to the disease; for it does not appear that children are ever born suffering from scrofula. It may probably be inherited either from parents who are scrofulous, or from those who are tuberculous; and the predisposition may be so strong as to amount almost to preordination, when, for example, the disease is not averted even by the most ample and ably directed means.

Some children who are born thus predisposed to scrofula, are said to present certain general features of character and form which are significant of the disease. The dark type of strumous subject so frequently described, is perhaps more often met with than any other, but the cases related above show that the disease is not confined to the individuals of any type or types. On the other hand, the features of the individual are liable to be seriously modified by scrofula. The upper lip may become large and tumid, the face coarse, the eyelids red and swollen from repeated attacks of inflammation; so that scrofula may often be easily recognized by the changes it has thus induced. Even the anæmia so frequently observed in scrofulous subjects, is said by Birch-Hirschfeld[2] to be a result and not a precursor of the disease, which occurs as often in those who are full-blooded and in whom the normal ratio of the two forms of blood-corpuscles is preserved.

Prognosis of Scrofula.—The manifestations of scrofula are the same at all periods of life, and similar tissues and organs are liable to be attacked. But while there is said to be a natural tendency towards recovery in young subjects, aged persons undoubtedly grow worse, not better. The prognosis depends, however, not merely on the age of the individual, but on the parts which are affected. Affections of the skin and mucous membrane, for example, may exist for many years with scarcely an appreciable effect upon the general

[1] Clinical Lectures and Essays, 2d ed., p. 359.
[2] Ziemssen's Cyclopædia, vol. xvi. English translation, London, 1877.

health; but suppuration in connection with large bones and joints is peculiarly fatal, on account of the diseases which it may induce, such as hectic fever and amyloid degeneration.

Treatment of Scrofula.—Fortunately, scrofula at all ages and in all its phases, is fairly amenable to treatment. The disposition, which is inherited, cannot perhaps be eradicated, but most of the lesions may by appropriate means be much improved, if, indeed, they cannot be completely cured. The treatment must be both general and local, for many affections which resist either form of treatment alone, will yield to the combined influence of both. The chief obstacle to successful *constitutional treatment* is the lack of ample means to carry out what is most desirable. For as the children of the poor furnish by far the most numerous body of patients, chiefly by reason of their poverty, so one of the main difficulties in treatment is the continual struggle with poverty. The parents are recommended to clothe their children warmly, to feed them on plain but good and nourishing diet, to place them where they may drink the purest water and breathe the finest air, to preserve them from frequent wet and cold, or send them where they may enjoy the advantages of sea-air and warm sea-baths—advice for the most part admirable, but as impracticable as admirable, for all these things are far beyond the reach of the poorest classes.

By the establishment, in large towns, of hospitals especially devoted to certain scrofulous affections, an attempt has been made to supply the food, warmth, and attention, which poor people cannot obtain at home; and by the foundation of country convalescent homes, something has been done to alleviate the sufferings of the scrofulous poor. But in the large cities of the old world, scrofula in various forms abounds, and the good which is accomplished by charitable institutions produces scarcely an appreciable effect upon a mass of misery so vast. It has been suggested that the air of hospitals is injurious to scrofulous patients, particularly where numerous suppurating wounds are treated. But while it may certainly be admitted that country patients are not likely to derive benefit from a prolonged residence in the hospital of a large city, there can be just as little doubt that the poor dwellers in large cities often owe their lives to the cleanliness with which their scrofulous sores are treated in hospitals, and to the food and medicines which they there receive.[1]

Not only are food and air and clothing useful, but certain medicines enjoy a well-merited reputation for their efficacy against scrofula. Of these, cod-liver oil is probably the most valuable, administered either alone or in combination with other remedies. It should be given once or twice a day, in doses varying from one to two or three fluidrachms, quickly after the taking of a meal, when it is least likely to produce gastric disturbance. Its use may be continued during many weeks or months, but it is better at intervals to leave it off. It may, for example, be drunk every day for fourteen days, and then remitted for a week; by this means the indigestion and nausea it is liable to produce may be avoided. It can scarcely ever be tolerated in the summer, but fortunately is not then so necessary as during the cold season. In the summer too it quickly becomes rancid unless kept in a perfectly cool place, and on this account is not a suitable medicine for out-patients during the hot season of the year. Children speedily learn not merely to tolerate, but even to like the oil, and will often take it greedily, especially when cer-

[1] With regard to the advantages of sea-air and warm sea-baths, there exists at present some difference of opinion. It has, for instance, lately been asserted that on scrofulous affections of the eye, the effect of sea-air is positively prejudicial, and that inflammations of lymphatic glands and bones remain stationary at seaside places. (Birch-Hirschfeld, loc. cit.)

tain syrups are mingled with it; and many adults acquire a certain taste for it, or at least cease after a while to regard it with disgust. In cases, however, in which the distaste is so great that it cannot or will not be overcome, cod-liver oil may be given in a peculiarly refined form, that, for instance, of the *perfected cod-liver oil*, or in combination with certain preparations which almost completely deprive it of its obnoxious qualities, such for example as maltine. Next in value to cod-liver oil are the preparations of iron, the syrups of the iodide or the phosphates, administered either alone or in combination with the oil. They are indicated where anæmia is a prominent feature of the disease, and may in all cases be employed in the intervals between the administration of oil, or during the summer.

It need scarcely be remarked that when other diseases are associated with scrofula, the remedies which are employed should be such as are appropriate for their treatment as well as for that of the scrofula itself. Thus, when syphilis is acquired by a scrofulous subject, the milder preparations of mercury, such as the bichloride, may be exhibited together with iron and cod-liver oil; and iodide of potassium may be given with iodide of iron with the best result.

The *local treatment* of scrofulous affections is exceedingly important, although in most of them the same general principles are involved as in the treatment of non-scrofulous affections of the same structures. The rest which is essential for most *joint-inflammations*, is quite as essential for joint-inflammations which are scrofulous. But if rest can be obtained by the aid of some apparatus which does not necessitate rest for the whole body, a great advantage will generally be gained. Operations are performed for the removal of *necrosed or carious bone*, equally whether the patient is scrofulous or not, although in the former case the prospect of cure of the disease by operation is greatly lessened. Many cases of scrofulous caries are, however, better not treated by operation. Of such are the swollen and "blown-out" phalanges, of which the fore-finger of the old woman furnished an example. They occur frequently in children; sinuses forming, through which soft, carious bone, or a soft pulp in which lie grits of bone, may be distinguished. The temptation is strong to interfere, to cut through the thin shell of bone and clear out the cavity within. But the usual effect of operation appears to be to light up fresh inflammation, or to leave wounds which will not heal; while the original disease, had it been left to itself with a strip of lint or other covering around the finger, would have almost surely healed with less delay—with shortening of the finger, no doubt, and with puckered scars, but with less deformity than after operation. Carious patches of the bones of old people who are scrofulous, should be operated on only with the greatest caution, if at all. For the parts are apt to resent the injury of an operation, and the wounds inflicted show no tendency to heal. Of scrofula in the aged, it may be generally stated that the ordinary specific remedies, local and constitutional, are much less efficient than when employed for younger persons, and that good food, warmth, and rest, are, in such patients, more than ever necessary for its treatment.[1]

Scrofulous *abscesses*, if they are not very large, may be opened in the usual manner; but the extensive cold abscesses of the pelvis and abdomen, generally associated with diseased bones or joints, should be left to point and break; or if they will not do so, but slowly burrow between the structures of the thigh or buttock, should be evacuated with every antiseptic precaution. Small abscesses about the neck and face may often be treated with the happiest result by aspiration. Even when matter is pointing, and the skin so

[1] Sir James Paget, loc. cit., p. 344.

thin and red that it seems as if it must give way, breaking may often be prevented by thrusting an aspirator-tube through the normal tissues at some distance from the abscess, into its cavity, and drawing off the pus. The gentle pressure of a pad and bandage will prevent refilling. By this means not only is tedious suppuration avoided, but no appreciable scar remains.

Scrofulous *ulcers* are often very difficult to treat successfully. They commonly require stimulation, and frequent change of stimulation. One of the best applications is finely-powdered iodoform, not pure, but mixed with thrice its bulk of oxide of zinc or starch. The ulcer should be cleansed and dried, dusted over with the powder, and covered with a piece of soft rag or lint. Nitric oxide ointment of mercury [Unguent. hydrarg. oxidi rubri], black wash, and other similar applications, may also be advantageously employed. But when the progress of an ulcer is very tedious, and its edges are undermined, I have often seen a marvellous improvement produced by freely cutting away the edges to the surrounding healthy tissues. The area of the ulcer is by this means widely extended, but healing generally rapidly ensues, and the remaining scar is far less unsightly than that which might be expected from the healing of the ulcer as it existed before the operation.

The treatment of *enlargement of the glands* is most unsatisfactory. The apparent cause of the enlargement may be removed, and the health improved by various constitutional measures, but the glands remain enlarged, or vary in size from time to time. No local treatment appears decidedly to influence their course. The action of counter-irritants is so uncertain that, although they are used, they often do more harm than good, appearing to excite rather than allay the unhealthy processes. The question of removal of such glands is scarcely more settled than the question of removal of tuberculous glands. Where only one or two glands are enlarged, and the enlargement has existed for many months or years, operation may be practised with success; but the danger is ever present that the wound may heal indifferently, and be a source of more distress than the disease for which it was inflicted. The obstinate sores and sinuses connected with caseous cavities in glands, may best be treated, not by excision of the glands, but by opening up the wounds, and scraping carefully away the caseous material with a silver spoon or scraper.

Lastly, it is sometimes advisable that the unsightly *scars* left by old scrofulous sores should be treated. More than once I have been applied to by young women, otherwise well-looking, whose necks were disfigured by numerous scars, the remains of scrofula in childhood. Thus prevented from obtaining good situations as servants or governesses, they are urgent for an operation. Nor is there any sufficient reason why, if all active signs of scrofula have long ceased to exist, an operation should not be practised. The most prominent ridges may with advantage be removed, and deeply indented scars be raised by the operation recommended by Mr. Adams.[1]

[1] Observations on Contraction of the Fingers, ... also on the Obliteration of Depressed Cicatrices, etc. London, 1879.

RACHITIS.

BY

J. LEWIS SMITH, M.D.

CLINICAL PROFESSOR OF DISEASES OF CHILDREN IN THE BELLEVUE HOSPITAL MEDICAL COLLEGE, NEW YORK.

RACHITIS, or rickets, is, in the plan of this work, considered as a constitutional disease, but it would seem in some respects equally in consonance with observed facts, to regard it as a disease of the osseous system, in which, in certain cases, other systems are secondarily affected. It occurs in the first years of life, and, therefore, during the period of most active growth of the skeleton. It is characterized by an abnormal nutrition and changed physiological action of the bone-producing tissues, namely the epiphyseal cartilage and the periosteum, and by the arrest, more or less complete, of the deposition of lime salts in these tissues.

FREQUENCY OF RACHITIS.

Rachitis is a common result of faulty diet and of anti-hygienic conditions, and is, therefore, frequent among the poor of cities, and especially in families who dwell in crowded tenement houses. It has, heretofore, been prevalent in the city infantile asylums, but of late years, as regards at least the city of New York, it is much less common, in consequence of the greater attention now given to sanitary requirements in the management of these institutions. Mild cases of rickets are often overlooked, since physicians may not be summoned to attend them, while even if they be summoned, many, who have not given particular attention to this disease, are apt to err in diagnosis, and to refer the symptoms to some other than the true cause. Commencing gradually and insidiously, rachitis not infrequently continues for months, even in its typical form, before a correct diagnosis is made. In the absence of deformity, which is a late symptom, the fretfulness, tenderness of surface, and perspirations, receive a wrong explanation. Practitioners who have heretofore given little attention to this malady, and who believe it to be rare, if they are instructed in reference to its characteristic signs, and look for them in their visits among the city poor, are surprised at the number of cases with which they meet. A few years since, in the New York Infant Asylum, my attention was directed to a rachitic child, whose head had so changed from the normal shape that the nurses, as well as the physician, had remarked the difference. Prompted by the occurrence of this case, which had gradually developed under my eyes, I made a careful examination of all the infants, and discovered, what I had not previously suspected, that about one in every nine had become rachitic. In most of the infants the disease was mild, but with symptoms so characteristic that it was readily recognized. By effecting certain improvements in the diet, among which was the daily

allowance of beef-tea to the older infants, rachitis, unless of a mild type, has since been rare in this institution.

The late Dr. John S. Parry, of Philadelphia, stated that at least twenty-eight per cent. of all the children, between the ages of one month and five years, who came under his observation in the Philadelphia Hospital during the three years preceding the publication of his paper, in 1872, were rachitic. This is certainly a larger proportion of those who present indubitably rachitic symptoms than occurs in any of the three New York institutions for children with which I have an official connection. In the New York Foundling Asylum, with its sixteen hundred inmates, and in the Bureau for the Relief of the Out-door Poor, where over eight thousand children are annually treated, rachitis is certainly less frequent than is indicated by the statistics of Dr. Parry. In Europe, from the testimony of many observers, both continental and British, rickets is very common among the families who seek medical advice in institutions of charity. Ritter von Rittershain finds that thirty-one per cent. of all the children who are brought to the Prague Medical "Poliklinik," are rachitic, and Prof. Henoch states that the proportion is equally large in the families of Berlin, who are in similar reduced circumstances. According to Dr. Gee, whose statement was, however, made as far back as 1867–68, of the patients under the age of two years, in the London Hospital for Sick Children, 30.3 per cent. are rachitic. Both Dr. Hillier and Sir Wm. Jenner not only allude to the frequency of rachitis, but state that it is the cause of many deaths in London families. It appears, therefore, that this malady, though not rare in the American cities where ill-fed and ill-housed families congregate, is less prevalent than in families similarly situated in Europe. The greater immunity in this country must be due to other causes besides difference in nationality, for the poor of the American cities are largely of foreign birth.

But rachitis does not occur exclusively among the poor. Children of well-to-do families are also liable to it, provided that the conditions soon to be enumerated are present. Ignorance or disregard of the hygienic requirements of young children, and especially the use of improper diet, leads to the development of rachitis in wealthy as well as in destitute families. Merei, in his treatise on the Disorders of Infantile Development (London, 1855), states that in Manchester, where his observations were made, one child in every five, in families in comfortable circumstances, presented rachitic symptoms; and he believes that this cannot be much above the real proportion in "the whole of the wealthy classes."

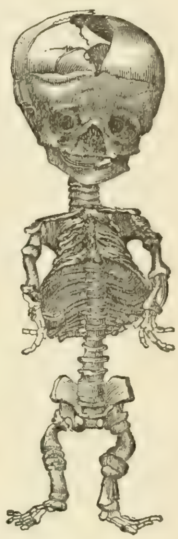
Rachitis, in its milder form, is not uncommon in affluent families in this country, the cause of the delayed dentition, fretfulness, and perspiration, not being suspected in many instances, as I have had opportunities to observe. Often family physicians are not consulted in reference to such symptoms, and when they are called in, so little attention has rachitis received on the part of many practitioners, that they are very apt to overlook the true pathological state which is present. Still, admitting the fact that many cases are not diagnosticated, I repeat that, though rachitis is not uncommon on this side of the Atlantic, its percentage of frequency falls below that observed in European cities, a fact which may be due to less crowding in their domiciles, and to a more liberal and better supply of food among the families of the poor in this country.

Age at which Rachitis Occurs.

Rachitis is, with few exceptions, a disease of infancy, commencing prior to the age of two and a half years. Now and then, it, or a state closely re-

sembling it, occurs in the fœtal state, causing deformities, such as are present in typical cases. In the Kinderspital Museum, at Prague, is a specimen showing this, and described by Ritter. Hink and Winkler also describe such cases, and Virchow alludes to a specimen in the Wurzburg Museum, which exhibits such deformities as characterize rachitis. Bednar even regards fœtal rachitis as not uncommon (Hillier, Parry). In the Wood Museum of Bellevue Hospital, is a skeleton which is probably similar to those in the Prague and Wurzburg Museums. It shows in a striking manner the deformities of this congenital disease. The case occurred in my practice, and the dissection was made by Prof. Francis Delafield. The infant, born at term, died a few hours after birth from atelectasis, apparently produced by the contracted state of the thoracic walls. The parents were hard working English people, whose mode of life and surroundings were such as are known to conduce to rachitis. They were free from syphilitic taint. The accompanying wood-cut (Fig. 9) represents this skeleton.

Fig. 9.



Skeleton of a rachitic infant, which died a few hours after birth.

The following remarkable case of supposed fœtal rachitis was related to me by Heitzmann, whose interesting experiments will be presently detailed:—

A woman who had frequently inhaled the vapor of lactic acid, each day, for many months, as she was employed to feed animals with this agent, gave birth to an infant, at term, which died immediately after it was born. It exhibited the signs of congenital rachitis in a high degree. The skull bones were completely absent; in the cartilages of the bones of the extremities, and in those of the ribs, there were scanty depositions of lime salts, and numerous infractions. The death of the child was evidently due to the absence of the skull bones, inasmuch as the pressure of the womb during delivery had caused cerebral hemorrhage. All the organs of the chest and abdomen were found in full development and healthy.

We will see, hereafter, that the theory which attributes rachitis, in certain instances, to a chemical irritant, is proved by experiment, and that it has already been shown that two such agents, phosphorus and lactic acid, may cause this disease. Now, as the irritating action of phosphorus on the osseous system occurs when it is inhaled in the form of vapor, as well as when received in the ingesta, so lactic acid, if the above case be rightly interpreted, produces its special effect upon the bone-producing tissues when inhaled, as decidedly as when received in the ingesta or generated in the system. These remarks seem necessary for an understanding of this unusual case, although they anticipate what will be said under the head of etiology. In the *New York Journal of Obstetrics* for November, 1870, Prof. Abraham Jacobi also published the description of a case of congenital rachitic craniotabes. Whether or not we accept as genuine all the reported cases of fœtal rachitis, there can be little doubt, from the number of observations already made and carefully recorded, and from the opinion of high authorities like Virchow, that such cases do occur.

Enlargement of the costo-chondral articulations, known as the "rachitic rosary," which is one of the earliest and most reliable signs of rickets, has been observed, though rarely, in infants only a few weeks old. Dr. Parry saw it as early as the sixth week after birth,[1] and Dr. Gee at the third or

[1] American Journal of the Medical Sciences, January, 1872.

fourth week.[1] This should not, however, be regarded as a sign of rachitis, unless the enlargement be so great that it can be readily appreciated by examination through the integument, or by sight, for in young children, with the bones in the process of normal development, these joints usually have a diameter a little larger than that of the ribs. Rachitis, with few exceptions, begins within the first eighteen months of life. Though first detected and diagnosticated at a later date, it will ordinarily be ascertained, on inquiry, that its symptoms had an earlier beginning. Still, according to certain observers, it may have a considerably later commencement. Glisson, Portal, and Tripier state that they have seen it commence in children who were well on towards the age of puberty. Sir Wm. Jenner states that he has seen children of seven and eight years, who were only beginning to suffer from rachitis.[2]

The following are the aggregate statistics of Bruennische, von Rittershain, and Ritsche, relating to the age at which rachitis occurs :—

	No. of Cases.
During the first half year,	99
" " second half of first year,	259
" " " year,	342
" " third year,	134
" " fourth year,	31
" " fifth year,	17
Between the fifth and ninth years,	21
Aggregate,	903

Causes of Rachitis.

Inheritance.—In some infants there is an undoubted hereditary predisposition to rachitis. Feeble digestion and defective assimilation in the infant, which are, as we shall see, important factors in producing the rachitic state, are often traceable to disease or cachexia of one or both parents. The offspring of a tubercular, syphilitic, or otherwise enfeebled parent, is more likely to become rachitic than those of healthy and robust ancestry; and it appears that disease of the mother is more apt to entail a rachitic predisposition than that of the father. Among the parental causes may be mentioned poverty, hardships, and defective nutrition of either parent; age of the father, and exhausting discharges of the mother, such as purulent, hemorrhoidal, or uterine fluxes.

Food.—Of the exciting causes, the most common is the use of food not sufficiently nutritive, or, if nutritious, not suited to the age and digestive powers of the child. Thin and poor breast milk, and artificial food of poor quality, or not suitable for the stage of growth and development, are common causes of rickets. Those children who have been prematurely weaned, and who have been given a food which is not a proper substitute for the natural aliment, and those too long wet-nursed and not allowed the additional aliment which they require, are especially liable to this disease. Those whose digestive power is feeble, from whatever cause, are more apt to become rachitic than those who, in a state of robust health, have a hearty digestion. Hence we meet with rickets as a sequel of various protracted and exhausting maladies during infancy.

[1] St. Bartholomew's Hospital Reports, vol. iv.
[2] Lancet, December 11, 1880.

It might be supposed, from the nature of rachitis, that the use of food deficient in phosphoric acid and lime was the common cause of rachitis; but facts show that this is not the correct view of its etiology, as it commonly occurs, although in its treatment these agents are of undoubted value. The disturbed and altered nutrition of the osteo-plastic tissues, namely of the epiphyseal cartilage and the periosteum, is the important factor in producing the rachitic bone disease, and this may occur although the ingesta contain a sufficient amount of phosphoric acid and lime. Deficiency of these substances probably tends to diminish the amount of lime deposition, but is not the essential element in the causation of the malady. This is to be found in the unhealthy condition and action of the cartilage and periosteum, or rather in the agencies, now partly ascertained, which produce the abnormal state and altered nutrition of these tissues.

Artificial Production of Rachitis.

The important fact has been ascertained by experiments on young animals, that rachitis can be produced, as I have already stated, by at least two chemical agents, which may be admitted into the system in the ingesta, and which exert an especially irritating action on the osteo-plastic tissues. Senator states, in Ziemssen's Encyclopædia, that "Wegner . . . has recently brought experimental evidence to show that true rickets may be artificially produced by the continued administration of very minute doses of phosphorus . . . together with a simultaneous withdrawal of lime from the food." The fact being established that it is possible to produce rickets by certain deleterious principles in the ingesta, opens an interesting field for experimental inquiry. Since improper feeding and indigestion are known to sustain a causative relation to rachitis, experiments have been made to ascertain whether some chemical agent, developed in the system during the digestive process, or introduced with the food, may not cause rachitis as it ordinarily occurs in the infant. Among the foremost in that line of experiment has been Dr. Heitzmann, a resident of Vienna when his observations were made, but now a citizen of New York.

In young children, acids, especially the lactic, are commonly produced, and often in large quantities, as the result of improper feeding, of indigestion, and of intestinal catarrh. The acidity of the infant's stools, under such conditions of ill health, is well known. What more natural, then, than the supposition or belief that this acid, thus generated, sustains the same causative relation to rickets, as phosphorus in the experiments which have been made with that agent. But the acid which is produced so abundantly in disturbed states of the digestive apparatus in the infant, believed to be chiefly the lactic, must, in order to reach the bones and influence their nutrition, pass through the blood, which is always alkaline. This difficulty in the way of the theory that lactic acid is the irritating agent, is removed by physiologists who tell us that among the organic acids the existence of lactic acid in healthy blood is not entirely beyond doubt, but that it has been found in the latter under abnormal conditions.[1] Lactic acid has also been found, after having made the circuit of the system, in the excretion from the kidneys.

Heitzmann, in order to ascertain whether this acid sustained a causative relation to rickets, made a series of experiments, which have passed into the literature of this disease, and he has kindly furnished me with their details, as follows:—

[1] Heinrich Frey, of Zurich.

Marchand, Ragsky, Lehman, Simon, and others have found free lactic acid in the urine of persons suffering from rickets and osteo-malacia. C. Schmidt discovered lactic acid in the liquid of malacic shaft-bones, which were transformed into globular cysts. Encouraged by these chemical researches, I undertook a series of experiments on the action of lactic acid, administered both by the mouth and by subcutaneous injection, upon the bones of living animals, which experiments were begun in April, 1872, and continued until the end of October, 1873. The experiments were made upon five dogs, seven cats, two rabbits, and one squirrel. On dogs and cats under one year of age, the lactic acid, given either by mouth or injection, in combination with restricted administration of calcareous food, produced swelling of the epiphyses of the shaft bones and of the anterior ends of the ribs, at their attachments to the costal cartilages. This result was plain in the second week after the beginning of the lactic acid treatment. Up to the fourth and fifth weeks, the swelling of the epiphyśes and of the ends of the ribs kept increasing, and then was accompanied by curvatures of the bones of the extremities. As accompanying symptoms, I noticed catarrhal inflammation of the conjunctiva, of the mucosa of the bronchi, the stomach, and the intestines, with emaciation and convulsive movements of the extremities. The microscopic examination of the epiphyses gave an image fully identical with that of the epiphyses of rickety children. Upon continuing the administration of the lactic acid, the swelling of the epiphyses of the shaft bones gradually increased, and so did the curvatures of the shaft bones. After four or five months of lactic acid treatment, under often repeated catarrhal inflammations of the above named mucous layers, the shaft bones became soft to such a degree that they could be bent like the branches of a willow-tree. After from four to eleven months of the same treatment, the microscopic examination of the bones gave a result corresponding with that obtained from the bones of women who have died with osteo-malacia.

On the three herbivorous animals no swelling of the epiphyses was noticeable. One rabbit died three months and the other five months after the commencement of administration of the lactic acid, but with symptoms of inanition. No marked evidences of rachitis or malacia were traceable in the bones of these animals. The squirrel, on the contrary, which died after thirteen months of treatment with lactic acid, gave all the features of osteo-malacia.

My experiments give the result that by continuous administration of lactic acid, at first rickets, and afterwards osteo-malacia, can be artificially produced in flesh-eaters; while in herbivorous animals, osteo-malacia sets in without preceding symptoms of rickets. Through these experiments I have proved the identity in nature of these two diseases, the differences in their course being due to the difference in the age at which the solution of the lime salts is established. . . Rickets can be produced on dogs and cats only under the age of ten or twelve months. Mr. Hess fed with lactic acid a dog of the age of one and a half years, and failed to produce rickets. This result is in full agreement with my experiments. I maintain that lactic acid, though not free in the blood, if in contact with the tissues producing bone, or with fully developed bone, owing to its great affinity for lime, either prevents the formation of bone (rickets), or dissolves ready-made bone (osteo-malacia).

On the other hand, rachitis sometimes occurs in infants who present no history of indigestion or of intestinal catarrh, and in whom there is no ground for the belief that lactic or any other acid is produced in undue or injurious quantity. In a considerable proportion of such cases, inquiry elicits the fact of anti-hygienic conditions, but there is no evidence of imperfect digestion, or of gastro-intestinal catarrh, such as produces lactic acid. In the cases occurring in the New York Infant Asylum, alluded to above, some of the children had manifest gastro-intestinal derangement; but others, who were wet-nursed, gave no evidence of faulty digestion, though the nutriment which they received was probably insufficient; for, as already stated, by providing a more liberal diet, by allowing among other articles the juice of meat, rachitis became much less frequent, and is seldom observed at present among the infants of that institution, unless in a very mild form.

Virchow and others have suggested that the prime factor in causing rachitis

is the use of a diet that is deficient in calcareous salts, and we have seen that in the interesting experiments of Dr. Heitzmann, the administration of calcareous food to the animals was restricted. Still, as Niemeyer has well said, deprivation or restricted use of the chalky salts cannot possibly cause the most important histological change in rachitis, namely, the proliferation of the epiphyseal cartilages and periosteum, and we must look for some other factor in the causation.

Pathology furnishes many examples of chronic disease attended by proliferation of tissue, the causes of which are not uniform. Cirrhosis, with its proliferation of hepatic connective tissue, which, as we shall see, presents a similitude in some respects to rachitis, is sometimes undoubtedly produced by the irritating action of a chemical agent, to wit, alcohol; but all physicians know that there are many cirrhotic patients who refrain entirely from the use of alcohol in any form. In like manner, it seems to me that, if we admit, as we must in the light of experiments, that certain chemical agents, notably phosphorus and lactic acid, introduced into the system or produced in it, cause rachitis by their irritating action, there are other typical cases in which there is no reason to suspect the operation of such agents. We must, therefore, remain in the belief that rachitis, like many other pathological processes, does not result from a fixed and uniform cause, but from conditions which vary to a certain extent in different patients.

Anatomical Characters of Rachitis.

For convenience of description, the course of rachitis is divided into three periods: (1) That of proliferation and altered nutrition of cartilage and periosteum; (2) That of curvature and deformity; (3) That of reconstruction.

Anatomical Characters in the Stage of Proliferation and Altered Nutrition.—Ossification of a long bone occurs from the epiphyseal cartilages, and from the periosteal or fibrous membrane which surrounds, nourishes, and protects the bone. Growth in length is from the former, in thickness from the latter. As regards the flat bone, while growth in thickness occurs from the periosteum, that in breadth is from the cartilage of its border, which corresponds with the epiphyseal cartilage of the long bone.

Cartilaginous Changes.—If we examine the epiphyseal cartilage of a long bone during normal ossification, we observe, first beginning at the distal end, a white zone, consisting of the hyaline matrix, in which are the usual cartilage cells. This constitutes most of the cartilage. Underneath this, and nearer the bone, is the *zone of proliferation*, the cartilage in which is softer and more yielding than that of the distal zone, in consequence of cell formation, and absorption of the matrix to make way for cell-groups. Each cartilage cell in the proliferating zone has divided into two cells, and each of these cells into two other cells, and the division has been repeated so that eight cells instead of one are observed, surrounded by a common capsule. The capsule becomes distended by the cell multiplication, and by the swelling of each cell, the size of which is considerably greater than that of the parent cell. Near the bone, namely, along the extremity of the diaphysis, the cell-groups, inclosed in their capsules, nearly touch each other, the matrix having, for the most part, been absorbed. The end of the diaphysis is covered with a layer of these cell-groups, about to undergo ossification, with almost no intervening matrix. The proliferating zone has very little depth. It appears

to the naked eye as a very thin, scarcely perceptible layer of a reddish-gray color upon the end of the shaft. It is so shallow that it does not perceptibly increase the thickness of the cartilage.

In rachitis, the state of affairs is different. The zone of proliferation, instead of being confined to a single, or at most double, layer of cell-groups, consists of many layers involving nearly the whole epiphyseal cartilage. The cells, still inclosed in their distended capsules, undergo a more frequent division than in health, so that instead of groups of eight cells, as in the normal state, each group consists of from thirty to forty cells. Therefore, in rachitis, the proliferating cartilaginous zone is a broad cushion, very soft, of a grayish translucent appearance, causing the characteristic swelling observed around the joint. Over the distal end of the proliferating cartilage, there may still be a layer or zone, though perhaps of little depth, of normal cartilage, like that in health.

Osseous Changes.—While this occurs, the ossifying process is also arrested. We indeed perceive an effort in the direction of bone formation. The Haversian canals, surrounded by capillary loops, extend from the bone into the proliferating zone of cartilage. Their extension is effected by absorption of the matrix and appropriation of cell-groups which lie in their way. The cells in these groups, as they enter the Haversian system, become much smaller by a rapid segmentation, forming medullary cells. We also find, as further evidence of the attempt at bone-formation, granules and masses of lime scattered through the cartilage, and here and there spiculæ and nodules of true bone, springing up from the bony substratum of the shaft. Some of the canals extend far into the cartilage, nearly indeed to its free surface, but most of them terminate in its lowest portion. The growth of bone in thickness occurs from the under surface of the periosteum. In health, a soft, vascular, germinal tissue springs from the periosteal surface, and rapidly receives lime salts, and is transformed into bone. This germinal tissue, consisting largely of capillaries rising from the fibrous tissue of the periosteum, is a very thin substratum, barely visible, transient, and constantly changing from its conversion into bone.

In rachitis, this vascular sub-periosteal tissue, not undergoing, or undergoing slowly and imperfectly, the osseous transformation, and at the same time increasing more rapidly than in health, under the irritating influence of the rachitic disease becomes a thick layer. Its color and appearance are like spleen pulp, so that the older observers supposed that there was a hemorrhagic extravasation between the periosteum and the bone. There is, however, no extravasation of blood, unless it accidentally occur from the numerous delicate capillaries. The resemblance to extravasated blood, or spleen pulp, is due to the abundant growth of large and thin-walled capillaries from the under surface of the periosteum, as shown by the microscope. This vascular outgrowth is, for the most part, quite uniform over the diaphysis of the long bones, while upon the cranial bones its thickness is much greater in one locality than in another. The attempt at ossification also appears in this tissue. Lime salts are scantily and loosely deposited through it, forming osteophytes—vascular and fragile—rather than true bone.

The question naturally arises: how does rachitis affect bone which is already formed when the rachitic state begins? Virchow's answer is the following: "Rachitis has . . . by more accurate investigation been shown to consist, not in a process of softening in the old bone, as it had previously been considered to be, but in a non-solidification of the fresh layers as they form; the old layers being consumed by the normally progressive formation of medullary cavities, and the new remaining soft, the bone becomes

brittle."[1] It seems, however, from the experiments of Heitzmann, that this opinion should be modified, at least as regards rachitis produced by lactic acid. Moreover, in rachitic cranio-tabes, occurring in infancy, there is certainly bone absorption, for portions of the occipital and parietal bones are absorbed to cause the soft spaces. We must, therefore, believe that there is in rachitis more or less absorption of lime salts in the bone, in addition to that required in the normal growth of medullary cavities and canals for vessels.

In healthy bone, the earthy salts are in excess of organic matter, nearly in the proportion of two to one; but in rachitis the proportion is reversed, the organic matter being much in excess. The following table gives analyses of rachitic bones by Marchand, Davy, Boettger, and Friedleben:—

	Femur.		Radius.		Vertebra	
	Inorganic.	Organic.	Inorganic.	Organic.	Inorganic.	Organic.
Case I.	20.60	79.40	21.24	78.76	18.68	81.32
" II.	37.80	62.20 (conval.)	20.00	80.00	32.29	67.71
" III.	20.89	79.11				
" IV.	52.85	47.15				

As might be expected, the relative proportion of organic and inorganic matter varies greatly in different cases, and at different stages of the same case. In severe rachitis many bones are affected. It is stated that there is no bone in the entire skeleton that may not suffer, but in mild cases only a few are involved, at least to such an extent as to produce structural changes, appreciable to touch or sight.

Pathology of Rachitis.—In this connection, it is proper to consider the *pathology* of rachitis. What is its nature?. Niemeyer in my opinion expresses the correct view, when he says "it seems to me that the most probable hypothesis regarding the cause of rachitis is that which refers it to inflammation of the epiphyseal cartilages and periosteum." The increased vascularity of the periosteum, the proliferation of periosteum and cartilage, the tenderness and pain on motion, and the febrile movement in acute forms of the disease, indicate inflammation rather than any other recognized pathological state. The rachitic inflammation as it affects the osseous system, appears to be of a chronic or subacute character, presenting an analogy with certain other well-known inflammations, such as cirrhosis and certain forms of chronic nephritis, in which proliferation of connective tissue and sclerosis occur. The eburnation rather than normal ossification, which terminates the rachitic process, may properly be considered an osteo-sclerosis. Conformably with the theory of the inflammatory nature of rachitis, the periosteum is found infiltrated and thickened, and of a reddish hue from hyperæmia, and from the presence of the newly-formed capillaries underneath, which have been described above as forming a layer of considerable thickness, known as the "germinal, vascular tissue." Moreover, as in inflammations, a secretion or exudation occurs over the bone from the under surface of the periosteum; it has a reddish, gelatinous-looking appearance. The various interspaces in long, short, and flat bones, the diploë, cancelli, and inter-lamellar openings, contain a substance similar to that exuded under the periosteum, resembling, says Trousseau, "red, pale gooseberry jam." It appears, like that under the periosteum, to be an inflammatory exudation.

[1] Cellular Pathology, Chance's Translation, Lecture xix.

Anatomical Characters in the Stage of Deformity.—Rachitic bone, when the disease has continued for some time and is still in its active period, presents a bluish or dusky-red appearance, from its increased vascularity. After a variable time, weeks or months according to the severity of the disease, deformities begin to appear.

Spiegelberg's description of the appearance of the rachitic fœtus corresponds for the most part with what I observed in the one whose skeleton is represented in Fig. 9. According to this writer, the body and limbs are plump: the latter short and curved; the abdomen large and prominent; and the head sometimes hydrocephalic. The skin is thick and loose, and the adipose tissue well developed; the liver large; the epiphyses swollen and soft; the short and curved diaphyses sometimes broken. The rotundity of the thorax is preserved, and the sternum is not carried forward, since there has been no respiration; the ribs, in softness and liability to fracture, correspond with the long bones of the extremities. The sternum, most of all the bones, shows the delay in ossification; the clavicle is among those least affected. The cranium may be represented by a membranous bag with *plaques* of bone, or the cranial bones may be formed and in shape, but thickened and softened; the sacral promontory is pressed forward and downward; the sacral vertebræ flattened; the ilia flattened and widened; and the pubic arch increased.

It is interesting to compare these deformities with those in the child, since they occur under conditions so very different. Rachitic bone seldom retains its normal form or shape; its projecting points are rounded, and, as soon as it softens, it begins to yield to pressure exerted upon it. Hence the curvatures, so common and characteristic. The portion of a long bone which is formed after rachitis commences, contains so little earthy matter that it bends readily in its fresh state, either by muscular action or by the weight of the trunk, "in the manner," says Vogel, "of a quill or willow stick." The interior of the bone, which was formed before rachitis began, and which contains nearly or quite the normal proportion of lime, is apt to break instead of bending, but, as it is surrounded on all sides by the soft tissue, the fragments are not displaced, and probably do not crepitate. So scanty is the calcareous deposition in typical cases, that, says Trousseau, "the bones . . . . can be cut with a knife with as much ease as a carrot or other soft root," and the dried specimen weighs but from one-sixth to one-eighth as much as normal bone. One writer states that the dried rachitic bone is sometimes so porous, from the small amount of lime which it contains, that it is possible to respire through it, as through a sponge.

In ordinary cases, the bones which exhibit most strikingly the rachitic change, and which, therefore, should be carefully examined in making the diagnosis, are the cranial bones, the ribs, and the radius—the sternal ends of the former, and the lower end of the latter. It is seldom that these bones do not give evidence of the disease, if it be present, and in greater degree than other bones. They are the first to be affected to an extent that is appreciable to the observer.

Changes in the Cranial Bones.—In these bones interesting and important alterations occur. Their edges, which correspond with the epiphyseal cartilages, undergo proliferation, and become thickened like the latter. This thickening, and the delayed union of the sutures, produce *grooves*, which can be traced by the fingers between the bones, and which are sometimes appreciable to the sight. Rachitis causes some *enlargement* of the cranium, but the enlargement seems greater than it really is, on account of the retarded growth of the facial bones. In a discussion on rachitis in the London Pathological

Society, reported in the Lancet,[1] it was stated that in seventeen rachitic children, with an average age of 4.72 years, the average circumference of the head was 21.22 inches, while in the same number who were non-rachitic, and with an average age of 6.05 years, the average circumference was 19.95 inches.

The retarded ossification is manifested not only in the open sutures, but also in the large size and patency of the *fontanelles*, which are not closed till long after the usual time. The anterior fontanelle should be closed between the fifteenth and twentieth months, but, in the rachitic, it remains membranous till after the second year, even into the third or fourth year. Since examination of the anterior fontanelle is important in determining whether or not rachitis be present, it should be borne in mind that, in the normal state, this space increases in size till the seventh month, when it is at its maximum, and that after the ninth month it becomes progressively smaller.

The *shape* of the rachitic head varies. In general, instead of its normal rounded form, it approaches a square shape. Another type is sometimes observed in which there is no marked angularity, but in which the antero-posterior diameter is enlarged. In the square head, the forehead projects, and both the frontal and parietal protuberances are unusually prominent. The sutures are depressed to a certain extent, as has already been mentioned, and the anterior, lateral, superior, and posterior surfaces of the cranium are more flattened than in health. The lambdoidal suture, which should close by the fourth month, and the sagittal, which should close by the end of the first year, have made little progress towards union when the second year begins. The undue prominence of the frontal and parietal bosses takes its origin from the exaggerated proliferation of the periosteal or fibrous covering of the bones.

Craniotabes.—Thinning of the cranial bones in places, so that the brain lacks proper protection, has long been noticed in the examination of rachitic heads, but the injury that results to the infant was overlooked till pointed out by Dr. Elsässer. Craniotabes occurs for the most part in patients under the age of one year, and a large proportion are under eight months. Its occurrence in the fœtus, as shown by a case published in the New York Obstetrical Journal in 1870, and by Heitzmann's case, has already been alluded to. The factors in producing this thinning are rachitic softening of the bones and pressure; pressure of the brain from within and of the pillow from without. Consequently, the portions of the cranial arch in which the thinning occurs are the posterior and lateral, the occipital bone and the posterior half of the parietal. If the infant lie chiefly on one side, in its crib, on this side the craniotabes occurs, while those portions of the cranium which are not pressed upon, as the frontal bone, exhibit no thinning. The soft spots are yielding when pressed upon, and in the cadaver they are seen to be translucent when held to the light. The amount of absorption varies greatly according to the degree of rachitic softening, and the amount and continuance of the pressure. There may be in some instances simple depressions, like erosions in the bone, with a continuous but thin bony layer remaining, but in other cases, such as have been particularly examined and studied by physicians, the bone absorption is complete over areas of greater or less extent, so that the pericranium and dura mater are in contact. In examining a child for craniotabes, it should be borne in mind that the margins of the bones, even when there is no thinning, but thickening from the cartilaginous proliferation, are flexible in the rachitic. The pressure must be made in a direction away from the sutures, to ascertain whether craniotabes has occurred. The pressure

[1] Lancet, 1880, vol. ii. p. 1017.

should at first be made lightly and cautiously, with the fingers, for if there be total absence of bone, unless of very little extent, deep and forcible pressure might injure the brain, for so soft and delicate an organ, covered only by the scalp and dura mater, badly tolerates pressure. If the first examination detect no soft place, the fingers may be pressed more firmly against the scalp, when, if the bone be much thinned, so that there is only a small layer of the lime salts underneath, it will be found to yield. The sensation communicated to the fingers, when there is an open space in the cranium, and the dura mater and scalp are in contact, has been likened to that experienced when pressing upon a fully distended bladder. At a meeting of the London Pathological Society, reported in the *Lancet* for November 20, 1880, Dr. Lees presented statistics to show that craniotabes was one of the lesions of inherited syphilis; but whether it may result from syphilis or not, the evidence that there is a cranial softening which is strictly rachitic, appears, from repeated observations, to be sufficient.

Symptoms of Craniotabes.—As craniotabes gives rise to peculiar symptoms quite distinct from those of the general rachitic disease, they may be properly considered in this connection. Craniotabes usually occurs during the first year of infancy, and most frequently prior to the tenth month. The brain at this age is soft and yielding, since it contains a large percentage of water. Unless handled with care, at an autopsy, it is readily lacerated, and moderate pressure upon it is seen to disturb and move it at a considerable distance from the point of contact. It assists to a proper understanding of the symptoms of craniotabes to recall to mind the fact, well known to surgeons, that slight depression of even a small portion of the skull is apt to produce grave symptoms. It is not surprising, therefore, that craniotabes when there is a space of considerable size in the cranial arch, destitute of bone, is attended by symptoms due to the mechanical effect of external pressure, whenever a substance less yielding than the brain comes in contact with the unprotected part.

Since pressure from the pillow without, and from the brain within, is believed to be the cause of the absorption, the craniotabes must obviously occur in the posterior and postero-lateral portions of the cranium. Corresponding with this explanation of the causation, the thinning actually occurs in the occipital and posterior portions of the parietal bones, while the anterior halves of the parietal bones, and the frontal bones, are even thicker than normal, from the cartilaginous and periosteal proliferation occurring along the sutures and on the surface of these bones, as already described. It is well known that long-continued pressure produces absorption of calcareous matter even more readily than of soft tissues, as is shown in the absorption of a tooth of the first set by the growth of the dental pulp of the second set. In the normal growth of the skull, constant absorption of the under surface of the cranial bones is going on to make room for the enlarging brain, and when no calcareous deposition occurs upon the external surface to compensate for the loss within, we might expect even a greater amount of craniotabes than ordinarily occurs.

Every rachitic infant is fretful, but one with craniotabes is especially so, if the open spaces be of considerable size. If it lie upon the pillow, in its accustomed manner, and as is most natural for it, the unprotected portion of the brain may be so pressed upon by the weight of the head, that it feels uncomfortable. It does not have quiet sleep, probably because the cerebral circulation and functions are in a measure disturbed; it is apt to awaken readily and often, and frets till it is taken in the nurse's arms. Sometimes it instinctively seeks a position on the edge of the pillow, with the face downwards, and it becomes more quiet when resting over the nurse's shoulder with

the face backward. But if fretfulness, disturbed sleep, and the necessity of closer attention on the part of mother and nurse were the only ill effects of craniotabes, it would possess much less pathological significance than pertains to it. Pressure upon so delicate and important an organ as the brain, involves risks and produces serious symptoms in proportion to its degree. Even a slight injury of the skull which produces depression, though it may be of trifling amount, will cause serious forms of nervous disorder. So craniotabes is believed to sustain a causative relation in certain cases to one of the most dangerous of the neuroses, namely *laryngismus stridulus*, an affection which is also designated "internal convulsions," "spasm of the glottis," and "Kopp's asthma," although Kopp was not the first to describe and recognize the malady. The etiology of this neurosis has not been fully elucidated. It is certain that a large proportion of those who suffer from it are rachitic, and that it is more common and severe where rachitis is prevalent, as in England, than where it is rare, as in the rural districts of America. It is not often the cause of death in this country, and the fatal cases that do occur are only seen in cities, whereas in parts of Europe, where rachitis is much more common than with us, it causes many deaths.

Certain infants, when in a state of excitement, have what are termed "holding-breath spells." The face is flushed, and breathing ceases for some seconds, after which respiration returns and is normal. These attacks are unimportant, but they appear to be the same in nature with the more severe and dangerous seizures of laryngismus stridulus. They have no pathological significance, excepting as they show the same neuropathic state as that in laryngismus, and as they may be precursors of this disease. Laryngismus stridulus, or glottic spasm, is usually preceded by more or less impairment of the general health, and often by fretfulness, which is characteristic of the rachitic state; but the attack occurs suddenly, without premonition, and is of short duration. It begins with an arrest of respiration, a true apnœa, as if from paralysis of the respiratory centre in the medulla. The lips may be livid; a pallor spreads over the face; sometimes more or less rigidity of the limbs occurs, with carpo-pedal contractions, and after a few seconds, a quarter or a half minute, a long and deep but difficult inspiration through the narrow chink of the glottis follows, accompanied in many patients by a whistling or crowing sound, and the attack ends with, perhaps, a momentary look of bewilderment or dread upon the child's face. Now this disease, like eclampsia, does not have a uniform causation. In certain cases, it appears to be a reflex phenomenon, due to an irritant in some part of the system, as in the intestines; but many observations have established the fact that rachitis, also, sustains a causative relation to it. A large proportion of the infants, affected with laryngismus, exhibit unmistakable rachitic signs, and, in the opinion of many experienced observers, the exposed state of the brain affords explanation of the fact that so many of the rachitic have this neurosis. Still, from observations which I have made, and from those of other ob-

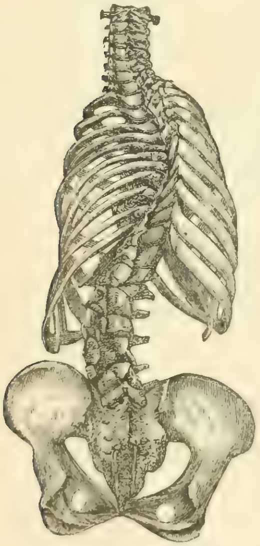
Fig. 10.

Head of a rachitic child in the New York Infant Asylum.

servers, like Senator, it is certain that laryngismus stridulus is common in the rachitic who do not have craniotabes, so that there must be a causative relation in rachitis to laryngismus independently of the cranial softening. The preceding wood-cut represents the rachitic head of a child in the New York Infant Asylum. This patient had also attacks of laryngismus stridulus.

Changes in the Vertebræ, etc.—The short bones which participate in the rachitic disease, become softer and more yielding, and their cancelli are filled with a reddish pulpy substance. In many rachitic cases, the vertebræ are but slightly involved, so that no deformity of the spinal column results; but occasionally, when many bones are affected, the vertebræ and inter-vertebral cartilages soften, and spinal curvatures result. The curvatures are due to the weight of the shoulders and head on the spinal column. They are, with some deviations, an exaggeration of those present in the normal state. Rachitic curvatures are, therefore, mainly antero-posterior with some lateral deflections. Where there is much curvature, the vertebræ become wedge-shaped, narrowed upon the concavity, and thickened upon the convexity. The inter-vertebral cartilages are also more or less changed by the pressure, being thinned where the vertebræ approximate to each other, on the concave aspect of the curvature, and of normal thickness or thicker than normal upon the convexity. The accompanying wood-cut exhibits the nature and appearance of rachitic spinal curvature in the adult. Rachitis, having occurred at the usual age, resulted in the permanent deformity here illustrated. In extreme cases, fortunately rare, the functions of important organs may be seriously impaired by the curvature and consequent compression, as in Pott's disease. Thus, according to Miller, the aorta has been so doubled upon itself as to materially diminish the flow of blood to the lower extremities, and to thus sensibly impair their nutrition. The effect of so great curvature upon the functions of the heart and lungs must obviously be detrimental.

Fig. 11.



Rachitic spinal curvature in an adult. (From a specimen in the Wood Museum, Bellevue Hospital.)

At first the spinal curvatures disappear when the child reclines, or is lifted by the axillæ, so as to raise the head and shoulders from the spine, but when the deformity has continued so long that the vertebræ and cartilages have become wedge-shaped, it remains for life, or can only be rectified slowly and with difficulty by mechanical appliances. As seen in the wood-cut, the common curvature in the dorsal region is backward (*kyphosis*), while to compensate the patient instinctively carries the neck forward, with the head thrown back, causing cervical *lordosis*, a similar anterior curvature being common in the lumbar region. Lateral curvature (*scoliosis*) may or may not be present, even when there is considerable antero-posterior flexure. Scoliosis is sometimes produced by the nurse, in carrying the infant habitually over one arm.

Changes in the Maxillæ.—Fleischmann has investigated the changes which rachitis produces in the maxillary bones. Stunted growth of the facial bones, generally, has long been known, and has been remarked upon by various writers; but, according to Fleischmann, other interesting changes occur in the jaw-bones, which affect the direction and position of the teeth. According

to this author, the arched shape of the lower jaw becomes polygonal, and the direction of the alveolar process also changes, so that it inclines inward. This deviation in the arch, and in the alveolar process, which begins in the region of the canine teeth, necessarily causes shortening of the lower jaw. Commencing soon after, a change is observed in the upper jaw-bone from the zygomatic arch forward, so as to cause lengthening of this bone, changing here also the shape of the arch and the position of the teeth. The lateral incisors, instead of being in front, have a lateral position, and the incisors and molars diverge, so that when the jaws are closed they overlap the corresponding teeth of the lower jaw in front and upon the sides, a condition the opposite of that seen in the jaws of old people. Fleischmann attributes these changes in the lower jaw to the action of the masseter and mylo-hyoid muscles, and perhaps the genio-glossus, and to pressure of the lip, the deficiency of earthy salts in the bone rendering it more easily acted on by the muscles. The change in the upper jaw-bone he attributes to lateral pressure of the zygomatic arches.

Changes in the Ribs.—The ribs are early affected in rachitis. The swelling of their anterior ends, where they unite with the costal cartilages, producing the "rachitic rosary," has been already alluded to as one of the first and most conspicuous signs of rachitis. The costo-chondral articulations are enlarged in all directions, appearing as nodules under the skin. If an opportunity occur of inspecting, at an autopsy, the pleural surface, the nodular prominences are seen to be even greater and more distinct there than under the skin.

Fig. 12.

Rachitic child with characteristic deformity of head, ribs, and radius. (From a patient in the New York Foundling Asylum.)

The deformity of the thorax consequent upon softening of the ribs is interesting. Commencing with the spine, the ribs extend nearly directly outward; at the union of the dorsal and lateral regions, they make a short curve forward, and then turn inward, also with a short curve toward the sternum (Fig. 13). This abrupt bending of the ribs, which, in their softened state, has been caused by atmospheric pressure during respiration, produces a depression in the thoracic wall at about the point where the ribs and their cartilages unite. A groove extends on the antero-lateral surface of the thorax from the second or third rib downward, and a little outward. Sometimes the bottom of the groove is occupied by the costo-chondral joints; in other cases these joints are a little to one side of the deepest part of the groove. The transverse diameter, therefore, of the anterior half of the thorax is much less than in health. This necessarily diminishes the lateral expansion of the lung in inspiration, and causes unusual prominence of the sternum. Hence the expressions "pigeon-breasted," "resemblance to the prow of a ship," etc., applied to this deformity. The presence of the heart renders the groove more shallow on the left side, at the fourth and fifth ribs, than on the opposite side, since this organ affords partial support to the chest-wall. On the other hand, the right groove is

not as long as the left, as the lower ribs on this side are partially supported by the liver. On both sides, however, the lower part of the thorax, that below the seventh, eighth, or ninth ribs, widens, being pressed outward and supported by the abdominal viscera. There is, therefore, in addition to the longitudinal groove, an antero-posterior depression, sometimes also spoken of as a furrow or groove, on either side, lying between the sixth and ninth ribs.

The ribs with their attached muscles are important agents in respiration, but the soft and yielding nature of the ribs, in the rachitic, retards, and to a great extent prevents, the lateral expansion of the thorax which is necessary for normal and full inspiration. The action of the respiratory muscles, and the pressure from within of the air descending along the air passages, is

Fig. 13.

Deformity of chest in rachitis.

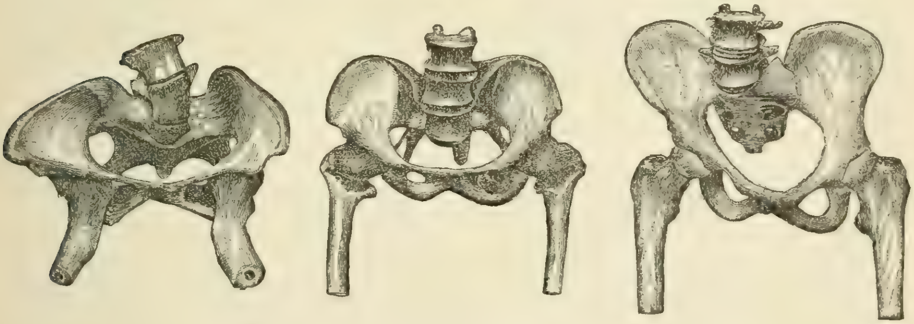
not sufficient to fully overcome the external atmospheric pressure, in the absence of proper resiliency of the ribs. Consequently, with each inspiration, we observe more or less sinking in of the thorax on either side, just as when a moderate obstruction to the entrance of air exists in the larynx or trachea. As the ribs become firmer from the deposit of lime salts, respiration is more regular and normal.

Changes in Bones of Upper Extremity.—Although swelling of the lower end of the radius (see Fig. 12) is one of the earliest signs of rachitis, the bones of the upper extremities are less frequently curved and distorted than those of the lower extremities. The *clavicle* sometimes softens and bends, producing two curvatures, one backward, near the scapula, and another of larger size nearer the sternum, directed forward and a little upward. Careful examination shows, in some rachitic patients, thickening of the margins of the *scapula*, like that of the cranial bones. The *humerus* is occasionally bent,

and usually at the point of insertion of the deltoid, in consequence of the powerful action of this muscle in raising and supporting the arm. The *radius* and *ulna* are bent outward and twisted. This deformity is attributed by Sir William Jenner to the fact that ricketty children support themselves, while in the sitting posture, upon the palms of the hands pressed upon the floor or couch. Supporting the weight of the body in this way, not only, in his opinion, causes bending of the ulna and radius, but also aids in producing the deformities of the humerus and clavicle.

Changes in Bones of Pelvis.—The deformities of the pelvic bones, resulting from rachitic softening, are, in the female infant, the most important of any which the skeleton undergoes. They are produced by pressure from above of the abdominal organs, serving to widen the brim of the pelvis, and also by pressure of the spinal column, sustaining the weight of the trunk, shoulders, and head, pressing forwards the promontory of the sacrum, in the sitting posture, and thus diminishing the antero-posterior diameter of the pelvic brim. There is, moreover, twofold pressure from below, that caused by the heads of the thigh bones, in standing, and that exercised by the tuberosities of the ischia, in sitting. Both these forms of pressure have a tendency to narrow the outlet of the pelvis. Hence the marriage of the female who has been rachitic in infancy may involve serious consequences. Many of the tedious

Fig. 14. Fig. 15. Fig. 16.

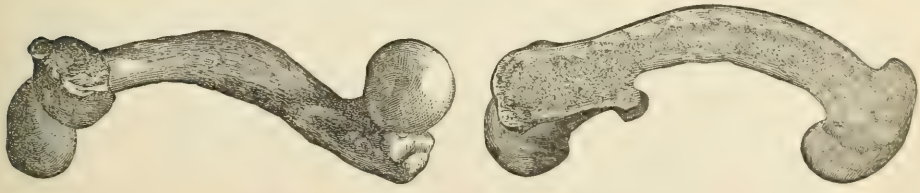


Rachitic deformities of the pelvis. (From specimens in the Wood Museum.)

instrumental labors in the families of the city poor, which severely tax the patience and endurance of young practitioners, are attributable to rickets in early life.

Changes in Bones of Lower Extremity.—The curvature of the *femur* is usually forward, or forward and outward. The neck of the femur sometimes

Fig. 17. Fig. 18.



Rachitic deformities of the femur. (Wood Museum.)

bends by the weight of the body, or by use of the legs, so that the angle which it forms with the shaft is changed. The annexed wood-cuts show the

rachitic bend of this bone in an adult, years after rachitis had ceased, and when the bone had become consolidated by the new deposition of lime salts.

The curvature of the *tibia* and *fibula* varies. In those under the age of one year, it is apt to be outward, so that the knees are separated from each other. In those old enough to stand, the weight of the body usually determines a forward bending of these bones. In one case in my practice, an anterior curvature so abrupt that an angle of about 70° was formed, existed about four inches above each ankle. This patient, though old enough to walk, almost constantly sat during the day with the feet extended beyond the sofa, so that the edge of the latter corresponded with the concavity of the legs. It seemed to me that the weight of the feet must have been a factor in causing these curvatures, especially as the case was one of very marked rachitic softening of different bones. Still, tibial and fibular bending at this point has been noticed by different observers, who have attributed it to the weight of the body in walking. Various other curvatures, besides those mentioned, occur in the bones of the lower extremities, the direction in which the limbs bend being determined by the particular circumstances of the case.

Fig. 19.

Fig. 20.

Rachitic deformities of the femur, tibia, and fibula. (Wood Museum.)

In mild cases of rickets, most of the deformities described above are lacking, but in typical cases certain of them stand out prominently, so as to be readily detected by one familiar with the disease. In all such cases the diagnosis is easy beyond that of most other maladies, for the changes which occur are not only conspicuous, but pathognomonic.

Rachitis produces another important effect on the skeleton. Its growth is *stunted*, not only during the rachitic period, but subsequently, so that those who have been rachitic in childhood, unless very mildly, have less than the average stature in adult life. The stunted growth is apparent, though ample allowance be made for curvatures. The arrest of development is greater in some bones than in others. It is greatest in the bones of the face, pelvis, and lower extremities. Stunted growth of the pelvic bones of the female infant conjoined with the deformities alluded to above, may seriously affect her subsequent life, and a rachitic pelvis in the female, exhibiting both stunted growth and deformity, constitutes a valid reason for avoiding marriage. As a rule, the older the child is when rachitis begins, the less is the skeleton affected, and the less consequently is the deformity.

Effect of Rachitis on Dentition.—As might be expected from the nature of rachitis, dentition suffers severely. If the disease show itself before any tooth has appeared, the first teeth, to wit, the lower central incisors, will probably not appear before the ninth or tenth month, or even later. Sir Wm. Jenner considers the non-appearance of a tooth by the ninth month, with few exceptions, a sign of rachitis. Teeth which appear during the rachitic state are frail, deficient in enamel, and crumble readily. They become carious, rot, and break before the usual time. If certain teeth have appeared when rachitis begins, several months elapse before others cut the gum. It is even said that a child who has rachitis severely may never have a tooth;

may remain toothless for life: but I have never observed such a case. Ordinarily, when the rachitic state ceases, and the health is fully restored, dentition goes on as before. The arrest of teething, so easily observed, has long been considered one of the most reliable diagnostic signs. The physician cannot justly pronounce on the nature of the disease in a case of suspected rachitis, unless he first carefully inspects the gums.

Changes in the Soft Tissues.—Although the conspicuous lesions of rickets pertain to the skeleton, the soft tissues are also more or less implicated. The *ligaments* become relaxed and flabby, giving unusual mobility to the joints, and unsteadiness to the movements. The fibrous bands which unite the vertebræ, as well as the ligaments of the extremities, participate in the relaxation. In certain patients, the *muscles* throughout the system, partly, perhaps, in consequence of the gastro-intestinal disturbance, indigestion, and mal-nutrition; partly, perhaps, from want of use (for the rachitic are apt to be quiet), become shrunken and flabby. The *spleen* is frequently enlarged, as ascertained by palpation and percussion. Ritter Von Rittershain found this organ decidedly enlarged in ten out of thirty-five cases which he examined after death. The enlargement is the result of cellular proliferation, common in diseases which are attended by dyscrasia. The *liver* in many patients undergoes no perceptible change, except that it may be pushed a little downwards. It is occasionally found enlarged from fatty infiltration, but no special significance attaches to this, for fatty liver is common in various forms of disease attended by innutrition and wasting. It is common in tuberculosis, and in protracted intestinal catarrh, and its pathological significance appears to be the same in these various diseases. There can be little doubt that Sir Wm. Jenner errs when he states that albuminoid infiltration of the liver is common in rachitis. Parry, Gee, Dickinson, and Senator agree that it is rare, and that if it does occur, it is by coincidence.

In a discussion on rachitis, in the London Pathological Society, Dr. Dickinson[1] spoke of enlargement of the spleen, liver, and lymphatic glands, which he had observed in rachitic cases. According to him, the spleen undergoes the greatest enlargement, the lymphatic glands the least, and, of the latter, "the mesenteric glands show the most decided swelling." Exceptionally, the spleen is so large that it occupies the greater part of the left half of the abdominal cavity, but a less degree of enlargement is the rule. The liver is apt to extend one or two inches below the ribs. The swelling, Dr. Dickinson adds, is not amyloid. "There is no new growth or deposit, only an irregular development of the proper tissues of the organs." Both the corpuscular and interstitial elements are increased in the liver, spleen, and lymphatic glands. But other members of the society had observed this enlargement only in occasional cases, and they considered it due rather to the state of health which caused rachitis than to rachitis itself. Dr. C. Hilton Fagge stated that he had failed to find swelling of the liver, spleen, or lymphatic glands, in a large majority of cases.[2] An undue development of the lymphatic glands from hyperplasia is very common in children in various states of ill-health, and the mesenteric glands are especially apt to become enlarged from this cause in protracted cases of intestinal catarrh or irritation.

The *abdomen* is *protuberant* from various causes. The lateral depression of the thoracic walls causes the liver and spleen to descend a little lower in the abdominal cavity than natural. The enlargement of the liver and spleen, the feeble tonicity of the intestinal muscular fibres, and consequent distension of the intestines with gas, and the rachitic shortening of the spinal column, which causes approximation of the ribs and pelvis, necessarily produce abdominal protuberance.

[1] Lancet, December 11, 1880. [2] Lancet, November 20, 1880.

The *kidneys* themselves are not diseased in rickets, but there is an exaggerated discharge of phosphates in the urine, and, as stated above, lactic acid and free phosphoric acid have been found in this excretion. The urine is commonly pale; its urea and uric acid are diminished; and it sometimes contains a sediment of oxalate of lime.

The *brain* is usually well developed, and appears healthy, with the normal proportion of white and gray substance. In one case the weight of this organ was ascertained by Dr. Gee to be fifty-nine ounces, and in another forty-two and a half ounces. In both brains the proportions of white and gray substance, and their color and consistence, seemed normal.

Anatomical Characters of the Third Stage, or that of Reconstruction. —This stage will be better understood, if we recollect what has occurred during the first and second stages. The very vascular periosteum is drawn tightly over convexities, the pressure upon which diminishes the hyperæmia and the amount of exudation underneath. Over the concavities the periosteum is loose; it is hyperæmic, with abundant new capillaries, the interspace between it and the bone being filled with the gelatiniform substance already described. The reparative process goes forward more rapidly, and the deposition of lime salts is more abundant upon the concave surfaces, where there have been free exudation and no compression of the capillaries, than elsewhere. The lime salts are deposited from the blood. Consequently, from the increased capillary circulation and hyperæmic state of the periosteum produced by rachitis, the chalky matter is rapidly effused wherever there is an open space under the periosteum, and where the capillaries are in a state of engorgement. Hence the reconstructed bone is thicker and firmer upon the concave aspect of the long bones than elsewhere, and thinnest upon the convex aspect where the periosteum is more tense, and its capillaries more or less compressed.

It is a question whether true ossification occurs at first during the reparative stage. The deposition of chalky matter is designated by some writers as a petrifaction rather than a true bone-formation. Trousseau likens it to the formation of callus after a fracture. It certainly produces a substance more compact than ordinary bone. The term "eburnation" has been applied to this new osseous formation, and I have designated it "osteo-sclerosis." Some years since I examined microscopically an adult bone which exhibited the rachitic curvature in a marked degree, and was very hard. It contained the elements of true bone, but I was in doubt whether the part examined was formed during convalescence from rickets, or in the subsequent growth.

Recovery from rickets is gradual. Little by little, the cartilaginous and periosteal proliferation ceases, the hyperæmia abates, and the bone-producing tissues return to their normal state. Certain of the deformities are permanent, but others disappear in the further growth of the skeleton.

Symptoms of Rachitis.

Preceding and accompanying rachitis, symptoms may be present which are due to indigestion and intestinal catarrh, such as flatulence, unhealthy stools, and poor or capricious appetite. When rachitis begins, the infant becomes fretful; its sleep is apt to be restless and disturbed, and it awakens often. It repels attempts to amuse it, and is apparently annoyed by them. Nurse and mother speak of it as a cross child. It perspires freely from the head and neck, both when awake and when asleep, while the extremities and trunk are dry. Its pillow is wet with perspiration during sleep, and sweat drops may be seen upon forehead and face. If the surface be dry, a little excitement or

elevation of temperature causes the perspiration to appear. The rachitic child does not well tolerate the bedclothes, and attempts to throw them off from its limbs, even in cool weather, lying exposed, and causing considerable annoyance to the nurse who strives to prevent its taking cold. Sometimes miliaria, due to the moist state of the skin, appear upon the face and neck. The subcutaneous veins which return blood from the head are large, and the jugular veins full.

Another symptom is soon observed, to wit, tenderness over a considerable part of the surface, perhaps largely due to the morbid state of the periosteum over so many bones, though it is also experienced when pressure is made upon soft parts, as the abdomen. The tenderness is probably, in part, the cause of the fretful disposition. The little patient appears to dread to be touched; its flesh is sore; it repels attempts to amuse it, and wishes to be quiet. Dandling it upon the arms, swinging it, or even walking with it, which delights the healthy child, and elicits a smile or notes of glee, only adds to its discomfort. It is most at ease when left alone, upon a soft cot or pillow, or, if it have craniotabes, when quietly held over the shoulder. Languor, disinclination to use the limbs, or to play, moderate thirst, with other symptoms referable to the digestive apparatus, which are present in many cases, and which have already been described, are soon followed by changes in the skeleton, which are perceptible to the sight and on palpation. The pulse and temperature in a large proportion of the ordinary chronic cases, do not deviate from the healthy state, except that in some patients there is a slight febrile movement in the latter part of the day.

Although rachitis is ordinarily a chronic disease, insidious in its commencement, gradual and progressive in its development, occupying months, there is an acute form which is attended by more marked febrile movement and tenderness, and in which the articular swelling appears more quickly.

A *bruit de soufflet*, of greater or less intensity, synchronous with the pulse, has frequently been heard in rachitic cases by applying the ear over the anterior fontanelle. Drs. Whitney and Fischer, New England physicians, first called attention to this murmur, believing it to be a sign of chronic hydrocephalus. MM. Rilliet and Barthez heard it in cases of rachitis, and, therefore, concluded that the American physicians had confounded the two diseases. More recent observations have established the fact that this *bruit* has little diagnostic value. It is heard whenever there is sufficient patency of the anterior fontanelle, both in health and disease, for sound is conducted better through a membrane than through bone. Dr. Wirthgen heard the *bruit* in 22 out of 52 children, of whom all except four were in good health. I have auscultated the anterior fontanelle in 29 infants, who were with two exceptions between the ages of three and thirty months. All were well, or affected merely with trivial ailments which did not affect the cerebral circulation. In most of them a murmur could be distinctly heard, synchronous with the respiratory act, and in 15 of the 29 cases no other sound could be detected, while in the remaining 14 a *bruit* could be detected, synchronous with the pulse.

Complications and Sequelæ of Rachitis.

These have been in part described in the foregoing pages, but there are certain other results of the disease to which it is proper to call attention. If the deformity in the thoracic wall, namely, the lateral depression of the ribs and anterior projection of the sternum, be great, we would naturally expect that the two important organs underneath, the heart and lungs, would receive some detriment. Upon the surface of the *heart*, at the point where it sup-

ports the softened ribs, a white patch is often found, due to thickening of the pericardium and proliferation of the endothelial cells, just as thickening of the skin in the palm of the hand occurs from friction and pressure upon that part. It is probable that this pressure does not seriously impair the function of the heart, but it may increase the weakness of its movements in any asthenic disease which may occur during the rachitic period. The injury sustained by the *lungs* is greater and more apparent. If the ribs be flexible, and much depressed, full inflation of the lung cannot occur in those parts where the depression is greatest. Semi-collapse of certain lobules is apt to occur, and even complete collapse of the distant thin edges of the lung. The stress of respiration falls unequally upon different parts of the lung. The anterior portion, which ascends with the sternum as that is propelled forward, is more fully dilated than the lateral and posterior parts, and hence is apt to become emphysematous. If in this state of the thorax and lungs, severe bronchitis or broncho-pneumonia arise, the state is one of great peril. The mucus and pus being expectorated with difficulty, clog the tubes and produce dyspnœa. Full inspiration in the lateral and depending portions of the lung, which is required in order to expel the mucus, not occurring, the result may be unfavorable, even in comparatively mild forms of inflammation. Bronchitis and broncho-pneumonia are the causes of death in not a few cases of severe rickets. Certain writers state that chronic *hydrocephalus*, *diarrhœa*, and *eclampsia* may complicate rachitis. I have not seen any case in which rickets seemed to sustain a causative relation to either hydrocephalus or diarrhœa, but we know that diarrhœa frequently precedes and accompanies rachitis, and its relation to it is that of cause rather than effect. This subject has been sufficiently treated of in preceding pages. Rachitic infants appear to be more liable to eclampsia than those who are healthy. This would be inferred from their liability to laryngismus stridulus, for there is a similitude in the nature of these neuroses.

Diagnosis of Rachitis.

Rachitis in many instances continues a considerable time before its nature is suspected, the symptoms to which it gives rise being overlooked, or attributed to other causes than the true one; and yet it is important that an early diagnosis be made, for it is much more amenable to treatment in its early than in its later stages. The deformities which mar the beauty, and to a certain extent impair the activity and usefulness, of so many who have been rachitic in childhood, may often be prevented by early diagnosis and treatment. Many with this disease do not show the usual signs of faulty digestion and innutrition, especially on casual inspection, for there may be considerable adipose development and rotundity of features and form in a rachitic child; while, on the other hand, there are numerous instances of mal-nutrition and wasting without rachitis. Early diagnosis, when the affection is of a mild type, is necessarily difficult, but a watchful and painstaking physician will commonly detect the disease before it has run many weeks, if he bears in mind its frequency, and looks carefully for it.

If called to a suspected case, we should inquire into the history, and particularly whether there have been signs of intestinal catarrh or innutrition. The gums should be inspected to ascertain whether there is backwardness in dentition, and the head, to note its shape and size, whether it is elongated, or whether it approximates the square shape, with broad forehead and large protuberances. We should notice also the state of the fontanelles and sutures, and whether there are softening and thinning of the cranial bones. The

costo-chondral articulations and those of the wrist, should also be carefully examined to ascertain if there is any enlargement, and the shape of the thorax, which begins to exhibit the rachitic deformity at an early stage of the disease, should likewise be noticed. We should also examine the child in reference to other less prominent signs, such as spinal curvature, abdominal protuberance, muscular weakness, and relaxation of ligaments (which produce feeble and unsteady use of the limbs), perspirations upon the head and neck from slight excitement, and during sleep, fretfulness, etc. If rachitis be present, certain of these signs will be observed.

The late Dr. Parry called attention to the importance of making a differential diagnosis between the *pseudo-paraplegia of rachitis* and true paraplegia, which is the prominent symptom of *infantile paralysis.* The rachitic child, from muscular weakness and ligamentous relaxation, and from the soreness and tenderness common in this condition, may seldom use his legs; may sit or lie quietly at the age when healthy children, if awake, are constantly moving their limbs. If we attempt to make him walk or stand, his legs may be so limp and powerless that they give way under his weight, but this is a different state from paralysis. In paralysis, the fault is in the nervous system—usually in the nervous centres—whereas, in rachitis, it is in the muscles and ligaments. The rachitic child, when sitting or lying down, readily moves his legs if his feet be tickled or pinched, while the paralyzed limb responds to the irritation imperfectly. In infantile paralysis, the loss of muscular power is, with few exceptions, confined to the muscles of the lower extremities; but in rachitis, the muscular feebleness is more general, being noticeable in the arms as well as in the legs. Great relaxation of the ligaments is in most instances due to rachitis. It is especially noticeable in the ankle and knee-joints, and is a diagnostic sign which should not be overlooked in the examination of a suspected case of the disease.

Prognosis of Rachitis.

The prognosis of rickets is usually favorable, provided that no serious complication arises. Rachitis is not in itself fatal, under ordinary circumstances. If there be much lateral depression and narrowing of the thorax, the functions of the heart and lungs may be embarrassed, and if the patient have a severe *bronchial catarrh*, or *broncho-pneumonia*, the condition becomes one of danger. Rachitic children seem to be especially liable to catarrhal attacks of the air passages, and even a moderate catarrh, with a deformed thorax, may prevent proper decarbonization of the blood, and cause lividity and dyspnœa. Therefore, now and then, a rachitic child succumbs to an attack of inflammation of the respiratory apparatus, which would not have been fatal if there had been no rachitic deformity. We have seen that in whatever way it may act to produce this form of spasm, rachitis is a cause of *laryngismus stridulus.* Occasionally spasm of the glottis is fatal, but cases with such a termination are rare in America, though not infrequent in some European countries.

Of the diseases of childhood which rachitic children tolerate badly, and which may prove fatal in consequence of rachitic bone-softening and deformity, *pertussis* should be mentioned. If this be severe while the ribs are soft and yielding, and there be lateral depression of the thorax, the spasmodic cough produces great suffering and involves danger. Lividity, feeble action of the heart, pulmonary and cerebral congestion, and eclampsia, may occur. *Measles*, if it be attended by considerable bronchitis, and especially if it be complicated by broncho-pneumonia, is also one of the dangerous intercurrent diseases. The gravity of these inflammations of the respiratory apparatus is

usually proportionate to the degree of recession of the ribs during inspiration. With these exceptions, and with that of risk to the married female who has deformity and stunted growth of the pelvic bones, the rachitic are not liable to any ulterior serious consequences. Minor deformities, in mild cases, not infrequently disappear in the subsequent growth of the skeleton. The older the child is when rachitis begins, the milder is ordinarily the form of the disease, and the more speedy, consequently, the recovery, and the less the deformity. In the gravest cases, the disease will almost always be found to have begun under the age of one year.

Treatment of Rachitis.

The correct treatment of rachitis is evident when we consider its character and the nature of its causes. The obvious indication is to restore healthy nutrition. This requires both hygienic and therapeutic measures. The apartment in which the child resides should be dry, airy, and plentifully supplied with light. He should be taken daily into the open air, in order to invigorate his system, but in such a way as not to increase his suffering, on account of his general tenderness. Residence in the country is far preferable to that in the city, because of the better hygienic conditions which it procures. The purer air, the better diet, and consequently the more robust development gained by rural life, are important advantages, to obtain which is abundantly worth pecuniary sacrifice when the children of a family are rachitic.

The *diet* in rachitis should receive particular attention, since indigestion and gastro-intestinal derangement sustain a causative relation to so many cases. Good breast milk ought if possible to be obtained until the child has reached the age of ten months, and, if the mother's condition be such that she cannot furnish it, a wet-nurse should, if practicable, be employed. But after the age of six months additional nutriment is required. As a rule, the infant should be weaned at the age of twelve months, but longer nursing may be best under certain conditions, as the presence of hot weather, an abundant supply of good breast milk, and, on the part of the infant, feeble digestion and easily deranged digestive organs. In case breast-milk cannot be obtained, cow's milk, properly diluted, according to the age, with water, or with a solution of one of the foods for infants which the shops contain, is probably the best substitute. I have stated that rachitis seldom appears before the age of three or four months. For an infant of four months, cow's milk should be diluted with about one-fourth part of water, but after the age of six months no dilution is required. I prefer to sweeten the milk not with cane sugar, but with Liebig's infant's food, prepared by Hawley, Horlick, or Mellen. Condensed milk is now much used in the cities, and is prepared by American companies as well as by the Anglo-Swiss company, but it possesses no advantages over ordinary milk, if the latter can be obtained fresh and sufficiently often. It possesses only the advantage that it can be longer preserved without fermentative change. Infants over the age of five or six months require the admixture of farinaceous food with the milk, at first in small quantity, but in greater proportion as the age increases. Barley flour, oatmeal, stale bread crumbled fine, Ridge's food, imperial granum, etc., of the shops, form suitable additions to the milk diet. For infants of the age of nearly one year, considerable variety may be allowed in the diet: a potato, baked and mashed like flour, the juice of beef, stale bread and butter, soda cracker and butter, etc., may be allowed. I have elsewhere stated that in one of the institutions of New York, rachitis from being common was made to disappear almost

entirely, by allowing a more generous diet, a part of which was the daily use of a little beef-tea. No absolute directions can be given, however, as regards the diet. Variation must be allowed according to the season of the year, and individual peculiarities. Cow's milk disagrees with some infants, and in hot weather with many; so that it is necessary to substitute for it some farinaceous food, with perhaps juice of meat, or the white of egg.

Medicines which improve the nutrition and general health are all more or less useful in the treatment of rachitis, but, from the nature of the disease, *lime* is specially indicated. I have not, like some observers, discarded the use of *cod-liver oil*, believing that it answers a good purpose in improving the general nutritive process. The following prescription will be found useful in most cases: ℞. Olei morrhuæ, f℥iv–viij; Aquæ calcis, Syrupi calcis lacto-phosphatis, āā f℥iv.—M. Of this, one teaspoonful may be given four or five times daily to an infant of one year. It may be too laxative in the summer months, when lime-water in milk, which is constipating, should be used instead. Fleischmann recommends the *fluorine* compounds in order to increase and harden the enamel of the teeth. I have had no experience with these remedies, but the theory of their use appears to be sound. He recommends the employment of fluorine between the tenth and eighteenth months, in the form of the tooth pastilles of Ehrhardt or Hunter, which contain the neutral fluoride of potassium. One of them is administered daily.

Among other agents which may be found useful may be mentioned the compound syrup of the phosphates, the citrate of iron and quinia, wine of iron, the various preparations of cinchona, calomba, etc., since such tonics when judiciously administered aid in the restoration of healthy nutrition. When complications arise, the treatment should be modified to meet the exigencies of the case. Most of the diseases which complicate rachitis require similar treatment to that which is appropriate in their independent form, but all measures of a depressing nature must be uniformly avoided.

SCURVY.

BY

PHILIP S. WALES M.D.

SURGEON-GENERAL OF THE UNITED STATES NAVY.

Synonyms.

Latin, *Scorbutus;* French, *Scorbut;* Spanish, *Escorbuto;* Italian, *Scorbuto;* German, *Scharbock.*

These appellations are derived from the old Saxon word *Scarbock* (ulcer of the mouth), or from the Sclavonic word *Scarb* (disease). We may define scurvy as an acquired, constitutional disease, determined by the use of improper diet, and almost wholly by abstention from succulent vegetable food. It is characterized by certain alterations in the vital, physical, and chemical properties of the blood, and by disturbances of the textural integrity of nearly all the constituent tissues and organs of the body. The perverted nutrition is manifested by lassitude, weariness, debility, breathlessness, loss of muscular power, depression of spirits, and hemorrhagic extravasations, particularly into the skin of the lower extremities; the cutaneous blotches (*petechiæ*, *vibices*, *ecchymoses*) are of varying size, color, and form. The skin occasionally is the seat of bleeding, inveterate, and sloughing ulcerations. Ecchymotic discoloration occurs also in the mucous membranes; the gums become spongy, and bleed easily, and the sanious discharges from them infect the breath with a foul odor. Blood is sometimes poured out into the visceral cavities and canals, giving rise to the various forms of local hemorrhage. The serous membranes display alterations of varying aspect, caused by effusive or inflammatory action. It may happen that exudative products occur in the substance of the viscera and organs, in which case they are exceedingly apt to light up inflammatory disturbances.

History of Scurvy.

There is no reliable evidence to be found in ancient medical literature that this disease was known as an independent and distinct pathological entity. Certain scorbutic phenomena were recognized, but always as allied and linked with those of other and diverse morbid conditions, as ergotism, typhus, diphtheritic stomatitis, malarial cachexia, splenic disorders, and icterus. There can be no doubt, however, that the conditions for its development were in early times frequently supplied by the prevailing and wide-spread ignorance and neglect of the plainest facts of sanitary prevision, by the frequent famines from failure of crops or other national calamities, by the movements

of large armies through uncultivated territories or desert wastes where food-supplies were impossible; by the recurring sieges of large cities; and, lastly, by the total neglect of horticulture which existed until a comparatively late period. These are the circumstances, at least, which in modern times have made a record teeming with the most destructive outbreaks of the disease. These *a priori* considerations tend strongly to an affirmative conclusion as to the prevalence of scurvy at all periods of the world's history, and render it probable that the failure to identify it was simply due to a lack of pathological discrimination. Various allusions to diseases presenting scorbutic phenomena can be gleaned from early authors. Hippocrates,[1] speaking of enlargement of the spleen (σπλὴν μέγας), enumerates such symptoms as a pallid skin, offensive breath, disease of the gums, and ulcers of the legs; and again in his description of the εἰλεὸς αἱματίτης, or *convolvulus sanguineus*,[2] he covers still more of the scorbutic symptoms, mentioning, in addition to the foregoing, epistaxis and impaired locomotion. Celsus,[3] Aretæus,[4] Cælius Aurelianus,[5] Paulus Ægineta,[6] Avicenna,[7] and others, have done little else than paraphrase the clinical descriptions of Hippocrates. Pliny,[8] in referring to the army of Cæsar Germanicus, states that a peculiar disease of the mouth, called *stomacace*, or *scelotyrbe*, affected the soldiers while encamped in Germany, near the sea-coast, and was attended with dropping out of the teeth and impeded locomotion; and he adds that in treating this malady the *Herba Britannica* and fresh vegetables were used with success. And Strabo[9] tells a similar story of a dangerous disease named στομακάκη, assailing the army of Ætius Gallus in Arabia. Marcellus[10] alludes to an ulcerative affection of the mouth, *oscedo*, for which he too recommends the *Herba Britannica*, a plant now believed to be identical with the *Rumex aquaticus*.

So run the historical and medical records as far as antiquity has shed any light upon this disease, and they are altogether too deficient and obscure to authorize any conclusion as to the real nature of the pathological processes intended to be described. The phenomena of scurvy are so peculiar, and the conditions of its occurrence so special, that it may well excite surprise that it was not recognized in the earliest times by those writers who, even now, are accorded the highest credit for their clinical acumen and precision. An explanation might be sought in the fact that the disease did not really prevail to any great extent in the mild climate and fertile lands of the south of Europe, in which the literary and medical writers of antiquity chiefly flourished, and where, it is well known, succulent vegetables grew luxuriantly, and formed a part of the common diet of all classes of people.

It is stated in the Book of Numbers (chap. xi.), that the children of Israel, in going through the wilderness, longed for the leeks, garlic, and onions upon which they had fed in Egypt, whilst Herodotus[11] tells us that not less than one thousand six hundred talents were paid for radishes, onions, and garlic consumed by the workmen employed in erecting one of the pyramids. In Rome, garlic (scorned by Horace[12] as only fit for the "dura messorum ilia") was also employed as a condiment, and the well-known proverb, "δὶς κράμβη θάνατος," proves that in Greece cabbages must have formed the most plebeian fare (Curran). So favorable a climate and such dietetic customs would not afford the same opportunities for observing the disease as the cold, inhos-

[1] Prorrheticorum lib. ii.
[2] Liber de internis affectionibus.
[3] De medicina, lib. ii. cap. vii.
[4] De causis et signis diuturnorum morborum, lib. i. cap. xiv.
[5] Morborum chronicorum lib. iii. cap. iv.
[6] De re medica, lib. iii. cap. xlix.
[7] Canonis medicinæ lib. iii. fen xv. tract. i. cap. v.
[8] Naturalis historiæ lib. xxv. cap. iii.
[9] Geographicorum lib. xvi.
[10] De medicamentis, cap. xi.
[11] Hist. lib. ii. Euterpe, cap. cxxv.
[12] Epodon lib., carm. iii.

pitable, and unfertile fields of the Northmen, where the difficulties of procuring abundant and varied food would be greatly enhanced, and where, as gardens were not cultivated, the people lived on salted or smoke-dried meats and fish. This rarity of horticulture finds illustration in the fact recorded by Hume, that Catherine of Arragon, Queen of Henry VIII., sent a messenger all the way to the Netherlands for the materials of a salad.

Following the current of history, a long period intervenes in which not a vestige can be found to indicate the occurrence of scurvy (unless we accept the rather doubtful story of the Norman hero Thörstein, who with a number of his fellows was supposed to have been destroyed by this disease in an expedition to Greenland in 1002) until the thirteenth century, when the religious agitation in Christian Europe led to attempts to rescue the Holy Land from the hands of the infidel. Hordes of undisciplined people, as well as regularly organized forces, then assembled for the invasion of Egypt and Syria. The lack of discipline, fatiguing marches, exposure to climatic vicissitudes, imperfect quality and quantity of the water supply, uncleanly camps, and depressing moral emotions from defeat, furnished the necessary conditions for the development of scurvy, and enormous loss of life followed. The first and fullest accounts were given by Jacob de Vitry, who describes the sufferings of the troops under Count Saarbrücken, lying before Damietta during the years 1218–19, after an overflow of the Nile, accompanied by heavy rains and the cold weather of December. He says:—

Invasit præterea multos de exercitu quædam pestis, contra quam physici nullum ex arte sua remedium invenire poterant; dolor repentinus pedes invasit et crura, et conjunctim caro corrupta gingivas et dentes abducit, masticandi potestatem auferens; tibias horribilis nigredo obfuscavit, et sic longe tractu doloris afflicti cum patientia multa migraverunt ad Dominum plurimi; quidam usque ad vernale tempus durantes, beneficio caloris evaserunt liberati.

A still more terrible epidemic afflicted the army of Louis IX., besieging Damietta in 1249, and was graphically described by Jean, Sire de Joinville.[1] The disease was attributed to the nature and scarcity of the army's food, which was chiefly fish, and to the character of the water; and it increased, says the historian, "to such a degree in our camp as to cause large masses of dead flesh to spring from the gums of our people. The barbers were forced to cut away the dead flesh to enable the patients to eat; the flesh of our legs shrunk up, and the skin was covered with red and black spots. Bleeding at the nose was a sign of approaching death."

Another gap, running over the period of nearly two centuries, and marked by total silence as regards scurvy, succeeded; Fabricius[2] was the first to relate the occurrence in 1446, in the north of Europe, of a new and unheard-of disease presenting scorbutic symptoms, which proved extremely fatal at various places in Norway, Sweden, Siberia, Russia, and Germany. The social and material condition of the masses of the people was of the most deplorable character; they inhabited foul, overcrowded, and closely-built dwellings, which exposed them to the worst consequences of impure air and bad drainage, while poverty added the ills of scant and improper food, and the rigorous effects of exposure to atmospheric vicissitudes. Although the districts bordering on the North and Baltic Seas were more particularly affected by these evils, yet the largest cities then presented a squalid aspect in striking contrast with the present spacious avenues, gardens, and imposing structures everywhere seen. Voltaire states that, about the year 1500, industry had

[1] Histoire de St. Louis IX., par le Sire de Joinville. Paris, 1761.
[2] Annales urbis Misnicæ.

not yet changed those huts of wood and plaster of which Paris was composed, into sumptuous palaces. London was still worse built, the Strand being composed of mud walls and thatched houses. These wretched hovels swarmed with people until after the great fire of 1666, when the houses were less crowded, one person occupying as much space as two in the old city. Yet, with this amelioration, the deaths from scurvy between the years 1671 and 1686, were 9451. For the period from 1686 to 1701, there were 1569 deaths, and only 226 between 1701 and 1776. This remarkable decrease took place *pari passu* with hygienic improvements both in the dwellings and food of the people.

The earliest account of the disease occurring at sea, is that related of a Venetian merchantman during a voyage to Norway in 1431. A little later (1497), the crew of Vasco da Gama,[1] in a voyage to India, experienced the most frightful sufferings from this cause, so that—

> "The livid gums with growth prodigious swelled
> Breathing infection that depraved the breeze."[2]

The sixteenth century was marked by frequent epidemics at various points in Europe and in North America, and during long voyages, and the disease was alluded to by numerous writers. Thus Euricius Cordus[3] in his Botanologicon, published in 1534, states that the herb Chelidonius minus, called by the Saxons *Scarbock crout*, is an excellent remedy for the disease, and the same fact is also alluded to by Julius Agricola[4] in his work Medicina Herbaria, published in 1539. Jacques Cartier[5] relates in an account of his second voyage, in 1535, that an epidemic of scurvy broke out among the natives of Stadacona, in the month of December, and also affected the people of his ships, so that—

> "By the middle of February, of 110 persons there were not ten whole. Some did lose all their strength and could not stand on their feete; then did their legges swel, their sinnowes shrinke as black as a cole. Others also had all their skins spotted with spots of blood of a purple colour; then did it ascend up to their ankels, knees, thighes, shoulders, armes and neckes; their mouths became stinking, their gummes so rotten that all the flesh did fall off, even to the rootes of the teeth, which did also almost all fall out."

He learned from a native the virtues of a decoction of the bark and leaves of a tree called *hanneda* (probably the American swamp spruce), the use of which cured his men.

The frequency of events analogous to the foregoing, both on shipboard and on land, invested the subject of scurvy with an interest and an importance that could not fail to lead to a more thorough investigation into its nature and causes. The first special treatise was published by Echthius,[6] a physician of Cologne, in 1541, in which he presented a fair summary of the phenomena of the disease as he had seen it, and differentiated it from other pathological conditions with which it had up to that time been confounded. He attributed the disease to alterations in the blood, and not to those of the spleen or other viscera, as had been erroneously done by his predecessors. Olaus Magnus,[7] in his history of the northern nations, bearing date 1555, gives, as of one of the diseases peculiar to them, a lengthy description of scurvy, vulgarly called *Scharbock;* ascribes its origin to the character of the food; and

[1] Hakluyt Society's Publication, p. 72.
[2] Camoens, The Lusiad; Canto V.
[3] Botanologicon. Colon. 1534.
[4] Medicina herbaria. Basil. 1539.
[5] Hakluyt, Principal Navigations, etc. London, 1598.
[6] De scorbuto epitome. Wittbg. 1585.
[7] Hist. de gentibus septent. Romæ, 1555.

recognizes its more frequent occurrence during famines and sieges: "est enim morbus castrensis, qui vexat inclusos et obsessos."

Two of the most important treatises were by contemporaries of Echthius, both based upon actual observation of the disease as it occurred in Holland. One was written by Ronsseus,[1] in 1564, and the other by Wierus,[2] in 1567. The former fell into the error of attributing the disease to splenic disorder. He regarded its prevalence in Holland as due to the peculiar damp air of the country, the use of impure water, and the perpetual diet of sea-birds and salt meats. Allusion is also made to the fact that seamen on long voyages cured themselves of the disease by eating oranges. On the other hand, Wierus adopted the views of Echthius as to the nature of the disease, and rightly attributed its cause to dietetic errors, and recommended for its cure the expressed juices of antiscorbutic herbs, or fresh herbs boiled in cows' or goats' milk, or whey. He regarded the disease as peculiar to the inhabitants of the countries bordering on the North Sea, and had never seen it in Spain, France, or Italy, nor in Asia or Africa. The treatise of Wierus was the standard authority until the end of the sixteenth century. The publications that followed — the chief of which were those of Langius,[3] Lommius, Dodonæus,[4] Brucæus,[5] Albertus,[6] and Forestus[7]—added little if anything to the information therein contained, but at the same time they rendered service by disseminating the knowledge already gained of the disease in those countries—Holland, Flanders, Brabant, etc.—where it was habitually present, and often epidemic.

The most ample opportunities were furnished during the seventeenth century for the attainment of correct notions of the nature and causes of scurvy, by the frequent wars and sieges on land, and by the maritime adventures and naval operations afloat. Among the most memorable may be noted the recital of Van der Mye,[8] of the suffering of the garrison of Breda during the siege by the Spaniards in 1624. The soldiers and the inhabitants of the town were generally affected, 1608 of the former having been attacked by the disease up to the fourth month of the siege, and the numbers increasing daily until the place surrendered in the following June, after an investment of eight months. The weather had been very wet, and the sufferers had been compelled to live on rye thirty years old, on cheese, and on dried fish. After the fall of the fortress, and the return of warm weather, the disease disappeared with the use of better food and a supply of vegetables. On the sea, the disease was rife everywhere. Sir R. Hawkins[9] relates, in the account of his voyage to the South Sea in 1593, that, during his twenty years of service afloat, upwards of 10,000 mariners had died of scurvy under his own observation. And, in 1609, three of the four ships that left England to establish the East India Company, lost nearly a fourth of their men by the time that they arrived at the Cape of Good Hope; while the fourth ship, the Commodore's, escaped almost entirely, in consequence of the men having been served each with a daily allowance of lemon-juice. On other occasions, the mortality of the East India Company's ships amounted to half of their effective force, and this devastation continued as late as 1775, when the hygienic reforms that had been introduced from time to time culminated in a better state of affairs, so that one ship made the entire voyage with the loss of but one man.

[1] De magnis lienibus, etc. Antuerp. 1564.
[2] Observationes med. Basil. 1567.
[3] Medicinal. epist. misc.
[4] Medic. observationes, etc. Lugd. 1585.
[5] De scorbuto propositiones. Rostock, 1589.
[6] Scorbuti historia. Wittbg. 1594.
[7] Obs. et curat. medic.
[8] De morbis, etc., 1627.
[9] Hakluyt Society's Publication.

Scurvy appeared in 1631 in the Swedish Army at Nuremberg,[1] and again in 1633 in Augsburg, and at the close of the century (1699) at the Hôtel Dieu, Paris. These examples serve to show how little advantage had been taken of the knowledge already gained of the causative influences determining the disease. In fact, the treatises that appeared at this time were inferior to those of the preceding century, and the most notable example was the book of Engalenus,[2] published in 1604, which, from the great esteem in which it was held for more than a century, served to disseminate the most absurd views concerning the pathology of scurvy. Scarcely an ailment was attributed to other than scorbutic influences, and certain peculiarities of the pulse and urine were regarded as the most certain and characteristic signs of their presence. This confusion—created first by Engalenus, and further extended by other writers who had adopted his opinions, such as Sennertus,[3] Willis,[4] and Lister[5]—induced not a few to doubt, and even to deny, the existence of scurvy as a distinct affection.

The eighteenth century, however, furnished the most marked examples of the devastation produced by scurvy, commencing with the siege of Thorn[6] by the Swedes, in 1703, in which 5000 of the garrison, besides many of the inhabitants, were destroyed by the disease, while the besiegers were absolutely exempt from it. When the investment ended, and succulent vegetables were permitted to enter the town, the disease quickly disappeared. It also occurred in Cronstadt,[7] Viborg, and St. Petersburg,[8] between 1731 and 1738, when thousands of common soldiers were cut off, but not a single officer suffered. The disease was so widespread and fatal that Kramer,[9] physician to the army, requested a consultation of the College of Physicians of Vienna. Their advice was, however, of no avail, for the disease, which had broken out at the end of winter, continued until the approach of summer, when succulent vegetables were procurable. Of four hundred cases treated with calomel, every one died. At the siege of Azof,[10] in 1736, the Prussians suffered severely, as did also the Russian Army, in 1742, at Viborg and other places. The malady was greatest during the winter and spring, and was ascribed to the unwholesome character of the food, and the want of fresh succulent vegetables. The dreadful misfortune of Admiral Hosier, who commanded the English fleet in the West Indies in 1728, presents an example of tragic interest: he lost two crews from the disease, and in consequence died himself, broken-hearted; and, a little later, the fleet of Admiral Rodney, on the same station, suffered severely. In 1740, Lord Anson left England with a squadron to circumnavigate the globe, and, after the most harrowing experiences from tempest and scurvy, returned with less than a fifth of his original force. The disease was fatally rife, though the men were abundantly supplied with fresh animal food. The fleet under the command of Admiral Geary, in 1780, returned to England with 2400 cases of scurvy, and the Channel fleet under Lord Howe was completely disabled from the same cause.

In 1749–50, the disease reigned in Friesland, and at Riga, Breslau, and Venice; and the British troops, 5000 in number, as related by Smollett,[11] were at the siege of Quebec, in 1760, so distressed by want of vegetables and the excessive cold, that before the end of April 1000 men died of scurvy, and more

[1] Rotenbeck et Horn, Specul. scorbuti. Norimb. 1633.
[2] De morbi scorbuto, 1604.
[3] Tractatus de scorbuto. Wittbg. 1624.
[4] Tractatus de scorbuto, 1667.
[5] Tractatus de quibusdam morbis, etc., 1699.
[6] Bachstrom, Observat. circa scorbut., 1734.
[7] Sinopeus, Parerga medica. Petersb. 1734.
[8] Nitzsch, Abhandlung des Scharbocks. Petersb. 1747
[9] Medicina castrensis. Norimb. 1735.
[10] A. Nitzsch, Theoretisch-practische Abhandlung des Scharbockes.
[11] History of England.

than twice that number were rendered unfit for service. Though the course of this century was marked by these lamentable occurrences on land and at sea, yet slow but steady hygienic improvements were discernible. The most eminent example of intelligent appreciation of their importance was that of Captain Cook, in a voyage of circumnavigation in 1772–75, which was accomplished with the loss of but a single man. This result was obtained by minute attention to the dryness, cleanliness, and ventilation of the ship, and by the use of suitable food. This example was not lost, for although the anti-scorbutic influence of fresh vegetables and fruits had long been a familiar fact, yet it was not until 1795 that the use of lemon-juice was made an integral portion of the ration of the British Navy by official order. The hygienic condition of that service has gradually improved since this period, so that scurvy has been well-nigh banished. These ameliorations have been chiefly due to the labors and writings of James Lind and Sir Gilbert Blane, the observations of the former having been printed in 1749, and those of the latter in 1785, and both having gone through several editions.

The nineteenth century has been marked by notable progress in hygienic knowledge, and scurvy has become restricted to narrower limits and to exceptional occurrences. At the siege of Alexandria, in 1801, which was commenced in May and ended in August, and which furnished, according to Larrey, the conditions for an outbreak of the disease, viz., cold, dampness, and bad food, 3500 cases were admitted into the military hospitals of the city, and many died. The disease was finally controlled by the issue of vinegar, dates, coffee, and syrup. The officers, who were well rationed, did not suffer. In 1809, the United States troops encamped in the Lower Mississippi, lost over 600 men from the disease. The army of Ibraheem Pasha, in Arabia, was so sorely beset by scurvy, that out of an army of over 100,000 men few returned to their homes, on account of insufficient food, harassing marches, and fatigue. The English troops in the war in Siam and Ava, supplied a large quota of cases of scurvy, and of scorbutic dysentery and ague; and in 1837, in the Caffir war, they were severely afflicted, for, although they were abundantly supplied with good fresh meat, they had long been without fresh vegetables and fruits. A similar experience occurred in the Punjaub, in 1848–49.

Scurvy had been seldom or never seen in Great Britain from the end of the last century up to 1847, except in jails and penitentiaries, as at Millbanke in 1823; but in the early months of 1847 and 1848, it made its appearance in many places, owing chiefly to the potato blight which destroyed the usual food supply. At this time the most terrific devastation from scurvy was reported in several of the Russian provinces. The total number of cases was estimated at 260,444 of which 67,958 proved fatal.

Dr. Gale[1] reported the sufferings of the American troops in 1820, in their march to Council Bluffs, which place was reached in October after weeks of the greatest hardships in navigating the boats up the Missouri River, during which time the men were exposed to the midday sun, evening dews and chilly nights, with food consisting chiefly of salted or smoke-dried meats, without vegetables or groceries of any sort. In the following January, scorbutic cases began to show themselves, but the disease proved fatal to few until February, when nearly the whole regiment sank beneath its influence, and it continued unabated until April when wild vegetables appeared. The strength of this post and of that at St. Peter's, was 1016; the number of cases 506; and the number of deaths 168. But one officer was affected, and the hunters who lived in the woods and subsisted on game were in no instance unhealthy. The

[1] Forry, American Journal of the Medical Sciences, N. S., vol. iii. p. 77.

United States forces[1] also suffered to some extent in the Florida and Mexican wars. Among the troops in Texas, between the years 1849 and 1854, of an aggregate force of 4450, 510 cases of scurvy occurred, of which three proved fatal. The disease was due to the frequent movements of the troops, and to the fact that the sandy and sterile nature of the soil in the vicinity of some of the posts offered insurmountable obstacles to the cultivation of gardens. The disease also prevailed at posts in the northwestern territory. Dr. Day remarks that during the winter of 1848–49, the disease appeared among the Indians. Their diet was poor and insufficient, but the scorbutic tendency among them was not nearly as great as among the whites; their powers of digestion and assimilation (when they have anything to digest and assimilate) being certainly better than those of almost any other people. Dr. Coale[2] reports the occurrence of scurvy in 1838, among the crew of the United States ship Columbus, in a cruise around the world. The ship left Norfolk, Virginia, in January, 1838, with a crew broken down in health, and, after leaving Rio, smallpox ran through the vessel. Off the Cape of Good Hope, a few weeks later, during a spell of cold weather in which the decks were almost continually kept wet, the first cases of scurvy appeared; and others continued to appear until January, when the ship reached the East Indies, where dysentery first, and afterwards diarrhœa, were added to the miseries of the crew. Dr. Coale remarks that the most fatal cases occurred among the most vigorous men; there were three cases of nyctalopia. The provisions served out contained only the ordinary navy ration, defective in fresh vegetables. Dr. Foltz[3] gives the history of an outbreak of scurvy in the United States squadron cruising in the Gulf of Mexico, during the summer of 1846. On board the Potomac, with a crew of 500 souls, 350 were disabled, and symptoms of the disease were present in most of those who remained on duty. The other ships suffered to a greater or less extent, particularly those that had been long in commission in the West Indies. The Mississippi, a steamer, made short passages at sea, and the crew, being enabled to procure fresh vegetables, suffered only to a trifling extent. In the British Navy,[4] between the years 1837 and 1843, there were 93 cases of scurvy returned from the East India squadron, 5 from the east coast of Africa, 13 from the West Indies, and for the other squadrons a still smaller number. Since that time the disease has had but a nominal existence.

The allied armies of England,[5] France, Sardinia and Turkey, during the Crimean war of 1854–56, underwent hardship and suffering of the most aggravated description, from vicissitudes of weather, physical fatigue, and deprivation of wholesome food and vegetables. The result was that in the British army there were reported during the whole period, 2096 cases of frankly expressed scurvy, while the taint was widespread, complicating other diseases, such as diarrhœa, dysentery, and malarial fevers, and greatly exaggerating their mortality, especially during the first six months of the siege. Of the total number, 178, or 8.4 per cent., died, the mortality having been almost entirely confined to the winter and spring of 1854–5. The disease began in October, 1854, gradually increasing during the following year, 1855, and in February reached its height, viz., 641 admissions. From this time it gradually subsided, so that by August the admissions were only three. In September of the same year it again increased, until January, 1856, when it reached its maximum, and then again it rapidly declined. The increased and

[1] Statistical Report of the U. S. Army, 1839–54, p. 369.
[2] American Journal of the Medical Sciences, N. S., vol. iii. p. 68.
[3] Ibid., p. 59.
[4] Statistical Report of the Health of the Navy.
[5] Medical and Surgical History of the British Army, 1854–56.

decreased prevalence noted, exactly accorded with the character of the food supply as to quality and quantity. In the early part of the war, this was of the most wretched kind; afterwards the greatest improvements were made, and with the most satisfactory results. The French fared even worse than the English forces, as regarded their supplies, and the consequence was the rapid appearance of the disease, so that 20,000 cases were reported; yet for the month of February, 1855, fresh meat of good quality, though lean, was issued, at first twice and afterwards five times a week; there was an irregular supply of bread, but rice was occasionally allowed, with dried vegetables such as peas and beans. With the opening of spring and the growth of vegetation, especially dandelion, which the men procured for food, the disease abated only to be renewed in the following July, when the hot, dry weather destroyed the greens attainable earlier in the year. The Sardinian and Turkish forces suffered, if anything, still more severely than their English and French allies.

During the war of the Rebellion, 1861–65, both the United States and the Confederate forces occasionally suffered from scurvy, or from its influence in other diseases. The cases of scurvy occurring in the various naval services, are isolated and infrequent, in consequence of the rigid hygienic measures now adopted. It has not been banished from the mercantile marine as it should be, yet the condition of the men in this service has been greatly improved by wise legal enactments. Since the passage of the Shipment Act, in Great Britain, in 1867, scurvy has decreased about 70 per cent. The "Dreadnought" Hospital-ship[1] still continues to receive annually an average of 90 cases, or about one twenty-fifth of all the cases admitted, due to the issue of improper food, or of rations defective in vegetable matter and acid juices. According to the report[2] of the U. S. Marine Hospital Service, there were admitted in 1873, 47 cases; in 1874, 59 cases; and in 1875, 25 cases; an average of nearly 44 for each of those years. The latest record of the general occurrence of scurvy was during the siege of Paris by the Germans, in 1872, from the usual cause —food deficient in fresh vegetable material.

Etiology of Scurvy.

Scurvy has no *geographical limitation.* It has prevailed in the extreme high latitudes of both the northern and southern frigid zones, on vessels engaged in arctic explorations, and among the native Laplanders and Esquimaux; almost everywhere within the temperate zones, in the eastern and western continents; and on numerous occasions both ashore and afloat in torrid regions[3] of the equator. It affects alike all races, the Caucasian, Malay, Negro, and Indian. Nor has it been confined to mankind, for at least one authentic case has been recorded by Bérenger-Féraud,[4] of a Gorilla having suffered from scurvy. All classes of society, rich and poor, high and low, are equally liable, whenever surrounded by circumstances that preclude the attainment of the requisite nutriment.

The disease has been observed at all *ages* from infancy to senescence; the orphan asylum at Moscow was invaded, alike with the asylum for the aged at Christiania. The crews of affected ships, and the forces holding besieged towns or fortresses, have suffered without regard to age. In epidemics, and

[1] Scurvy in Merchant Ships, 1865.
[2] Report of Supervising Surgeon-General, U. S. Marine Hospital Service, 1876.
[3] The seasons exercise no control over the occurrence of the disease other than that arising from their influence upon the growth of vegetation and upon human health, through the physical qualities of heat, cold, and dampness. Of the 68 epidemics, referred to by Hirsch, in which the season was noticed, 37 occurred in spring, 21 in winter, 8 in summer, and 2 in autumn.
[4] Comptes Rendus, 1858.

principally in those occurring during famines, observations have been made which seem to indicate a partiality of the disease to attack adults. Curran says that in all of his cases during the Irish famine, the age of the patients exceeded eighteen years, whilst at least two-thirds of the patients were beyond the middle period of life;[1] a circumstance that might easily be explained by the difference in the degrees of exposure, at different ages, to the determining causes of the disease. Nor would the youthful portion of a community be apt to be exposed in the same degree to the disturbing influences of tempestuous weather, exhausting labors, and depressing emotions. Old age brings with it mal-nutrition and debility that invite the speedy invasion of morbific causes.

Sex cannot be accused of any predisposing influence: statistical returns will, of course, show an excess of males, for the reason that they are more often under those conditions which determine the disease. It has occasionally happened, however, that more women than men have been attacked, as in the epidemic of 1813 in Southeastern Hungary; and in Croatia, in 1707, women only were affected. In the Irish famine, the proportion was about eleven males to one female.

It has been surmised that a *low temperature*, particularly when associated with dampness, fatigue, and mental depression, was a powerfully predisposing cause, if it did not actually originate the disease. M. Scoutetten,[2] in a communication to the Académie de Médecine on the epidemic at Giret, insisted upon these influences as all-powerful—an opinion which seemed to be sustained by the Academy. The Austrian war ship Novara, in her passage from Madras to Singapore, although, it is represented, abundantly supplied with fresh vegetables and acid fruit, was invaded by scurvy. The disease also occurred at Rastadt,[3] among the Austrian troops, when, according to Opitz, the only assignable causes were dampness and cold, the food not being defective in fresh vegetables. So, at Ingolstadt, the French prisoners in 1871 suffered, although abundantly supplied with potatoes and meat. In opposition to these views, it may be stated that the hottest and driest parts of the earth, as in India, the West Indies, and the interior of Africa, have been the scenes of as destructive outbreaks as those regions where the reverse conditions hold good. The greatest hardships have been undergone, without the slightest evidence of scorbutic taint affecting the sufferers, as long as proper alimentation could be maintained. On the other hand, inactivity has been regarded as a predisposing cause, and the alleged greater frequency of the disease among marines and skulkers of war ships, than among the seamen, is said erroneously to be due to this cause.

Depressing emotions, fear, anxiety, despair, etc., have been said to be able to determine the disease, and those of a reverse character to be able to check its progress; and our credulity is not a little taxed when we read the statement of Lind, that he has seen the scurvy, very prevalent and increasing in the fleet, at once arrested and quickly got rid of by the news of a successful engagement, or even the anticipation of one; or, more apochryphal still, the story of the Prince of Orange having arrested the disease by distributing a little colored water which was believed by the soldiers to be a wonderful and most expensive elixir. Monneret,[4] Fleury, and Papavoine,[5] have even asserted that they have seen scurvy result from mental influences alone in isolated cases.

[1] Dublin Quarterly Journal of Med. Science, 1847.
[2] Gazette Médicale de Paris, Juillet, 1847.
[3] Vierteljahrsschrift für die praktische Heilkunde, Bd. i. S. 114.
[4] Compend. de Méd., t. vii. p. 507.
[5] Journal Hebdom., t. ix. p. 321.

Foul air has no influence in determining the occurrence of scurvy, except in a general way by lessening the vital resistance, and thus hastening and intensifying the symptoms of this, as of any other disease depending upon a specific cause. Personal filth and foulness of the surroundings have also been erroneously held responsible for a share in its production. Even the pure air of the sea was at one time thought to be influential in exciting the disease, though little reflection was necessary to dispel this absurd notion. Scurvy has raged in inland towns and on fresh water courses, far away from the influences of a marine atmosphere. The opinion was even held that the circumstance of locality determined a difference in the nature of the disease, and hence the origin of the terms *land scurvy* and *sea scurvy;* whereas the fact is that there is no more pathological difference in these cases than there is in cases of pneumonia or typhoid fever occurring on shore and at sea. This view has been well nigh abandoned, though, as late as 1856, Dr. Crawford[1] emitted the same notion in relating his experience in the Crimea. He states that scurvy seldom exhibited there the characteristic features so often observed at sea, viz., the ulcerated and gangrenous gums, falling out of the teeth, abscesses and sloughing ulcers, contraction of the limbs, visceral effusions, syncope, and sudden death ; and adds that it would seem probable that the difference between land and sea scurvy was physiologically connected with the existence of diarrhœa and dysentery in the one case, and their absence in the other ; the affection as observed at sea being usually attended with a torpid or at least irregular state of the bowels. This opinion is erroneous.

In certain instances, the occurrence of scurvy has been supposed to be due to the use of *impure water*, as in the case of Ranke's expedition to the interior of Australia. There were two parties: one, thoroughly equipped and provisioned, suffered for the want of abundant potable water, and was attacked with the disease ; the other, less advantageously placed as regarded food and provisions, got all the pure water that they needed, and escaped. Other parallel cases are recorded, but they are entirely negative from the lack of certainty as to the exact nature of the food consumed. The more fortunate of Ranke's party may have partaken of succulent plants or esculent roots picked up on the journey. The various above-mentioned influences, whether ashore or afloat, are capable of deteriorating the nutrition of the body, and may in this way with truth be chargeable with promoting, under peculiar dietetic irregularities, the advent of an outbreak ; but neither singly nor combinedly can they determine it without this concomitant.

Individual peculiarities as to constitutional power and vital activity, exert a marked influence ; those of a weakly habit of body, either original or produced by accidental attacks of disease, are more liable than those in robust, vigorous health. Persons also who have been overworked or exhausted by excessive climatic influences, whether of heat or cold, more readily succumb. This was seen in the case of two ships of the United States, serving in the Gulf of Mexico : the "Raritan," coming from the coast of Brazil, had a crew enfeebled by long service in a hot climate, while that of the "Falmouth" was worn out by exposure to the cold, wet and boisterous weather of the northern coast of America, on which she had been serving. Both of these vessels suffered severely. In the same way, the deterioration of the vital powers brought about by an arctic voyage and a winter's residence in high latitudes, renders the men exceedingly liable in presence of the exciting cause of scurvy, and more so than those who are freshly arrived. There is no such thing as inuring the system to the unnatural surroundings of the arctic regions ; the longer the residence there, the more likely the disease is to occur. This state-

[1] Med. and Surg. History of the British Army, 1854–56.

ment is based upon experience, and readily commends itself to the judgment when the immense importance of sunlight upon the nutrition of the entire organic world is considered. One attack of scurvy confers upon its victim no exemption; on the contrary, it renders a second more probable, other circumstances being equal.

The frequent association of the scorbutic, with other pathological conditions, is well known, and doubtless forms one of the chief reasons why the early descriptions of the disease were so inaccurate, the complicating affections having being included in them. A frequent combination is with malarial disease, and it is easily appreciated that the slow and profound alterations induced in the blood by this miasm are well calculated to hasten the development of scurvy. The same influence is exerted by diarrhœa, dysentery, syphilis, hemorrhages, exhausting discharges, and the debility arising from prolonged suffering from wounds and injuries. In fact, any cause whatever that lowers the tone of the system and impairs nutrition, may be considered among the category of predisposing causes. It will be only necessary, in passing, to notice the fanciful idea of Travis,[1] that the use of copper vessels in the navy was a principal cause of scurvy; or that of Harvey,[2] who attributed it to gluttony or debauchery; or that of Maynwaringe,[3] that it was due to tobacco and excessive venery; or that of Willis,[4] who found its cause in the increasing consumption of sugar.

The evident connection between the character of the *food supply* and the occurrence of scurvy, attracted the attention of early observers, particularly Wierus and Echthius, who placed the cause entirely in errors of diet. This was the opinion also of Bachstrom, who published an essay on scurvy in 1734, in which he took the ground that abstinence from fresh vegetables was absolutely the cause of the disease, an opinion which was shared by other writers of experience, such as Rouppe[5] and Trotter.[6] This view has largely prevailed, and is now that which is accepted by most physicians. In 1847, Dr. Christison,[7] of Edinburgh, in a paper on the subject, attributed the prevalence of scurvy at Perth to deficiency in the quantity of azotized aliment and consequent insufficient nourishment of the body, and asserted his belief that milk, which supplied this deficiency, was an antidote for the disease. This theory, though ingeniously argued, is unsupported by facts; thus, for instance, in the north of Wales, where fresh meats and milk are abundant, and where the cottagers raise little or no garden produce, cases of scurvy appear every year; and, indeed, the whole history of the disease is at variance with this theory.

The habitual use of *salted meats* on ship-board, drew attention, naturally enough, to the causative relation of this sort of food, and not a few of the earlier observers have recorded their belief that it was the chief, if not the only, cause of scorbutic outbreaks. This statement has no foundation, however, for the very worst epidemics of the disease have occurred at sea, when fresh animal food has been abundant, and in communities on shore who never employ salt provisions of any sort in their diet. The disease will undoubtedly appear more speedily in those living on salt, than in those living on fresh, animal food; but from the mere fact that the nourishing power of the latter has been impaired by the removal to a greater or less extent of its albuminoid constituents in the salting process, and that, as a consequence, it possesses less power in sustaining the body. The withdrawal of both sorts of animal food would still more speedily, for the same reason, lead to the appearance of the disease. That salt in itself is impotent as a causative influence, is further

[1] Med. Obs. and Inquiries. London, vol. ii., 1762.
[2] The Diseases of London.
[3] Morbus polyrrhizos.
[4] Tractatus de scorbuto.
[5] De morbis navigantium, 1764.
[6] Observations on the Scurvy, 1792.
[7] Monthly Journal of Medical Science, 1847.

shown by the fact that large quantities of it may be given, as was done by Sir G. Blane, in scorbutic cases, without apparent deleterious effects. Simple deficiency in the *quantity* of the food also, it has been alleged, plays the most important *rôle* in the causation of the disease, and its prevalence during famines has been cited in evidence of the truth of this assertion. The fact is quite familiar, however, that scurvy is far from being an invariable accompaniment of famine, nor does it affect men on long cruises, or those shut up in besieged towns, when simply on short rations.

The *quality* of the food has as little influence as lack of quantity in producing the disease. Mouldy biscuit, and spoiled or even putrid meats, have been subsisted upon for long periods, and though the health has been thereby greatly impaired, no scorbutic condition has been produced.

From all the facts, both positive and negative, we may reasonably assume that the essential dietetic error leading to the development of scurvy, in the immense majority if not in all cases, consists in a deficiency in the *variety* of food; that is to say, that there is not the requisite proportion of animal matter with a diversity of vegetable substances. No single natural order contains plants that supply all the substances essential to the nutrition of the body and right composition of the blood; the graminaceous and leguminous articles of food, for instance, are numerous but not various; they all afford the same or analogous albuminous elements which have about the same nutrient value as the corresponding substances in animal food; and hence health and vigor cannot be sustained on a diet of animal flesh, combined with wheat, rice, and oat-meal, or with beans and peas, or with all of these together. Outbreaks of scurvy have occurred on ship-board where the ration is made up principally of these articles, as on Anson's ships when supplied with an abundance of fresh animal, farinaceous, and leguminous foods. In the epidemic that occurred at Carlisle and its vicinity, according to Dr. Lonsdale,[1] some of the railway excavators were affected, though they breakfasted off of beefsteaks or mutton chops, and partook of dinners composed of bread, boiled beef or bacon, pea-soup or broth, and suet puddings containing currants; but there were no potatoes nor fresh vegetables. It is clear therefore, that, in order to obtain the proper variety of materials required in nutrition, we must resort to several of the natural groups—those particularly which comprise the succulent vegetables and fruits.

What is the precise nature of the materials furnished by these latter, yet remains to be determined. Acid fruits, such as oranges, lemons, limes, etc., stand pre-eminent as antiscorbutics, and this fact led to the conclusion that their utility depended upon the vegetable acids which they contained, and the use of the latter in scurvy has been followed with a certain degree of success. Experience has shown, however, that the fresh juices and pulp of these articles, particularly when green, are more decidedly antiscorbutic than the same materials when prepared by the various methods of drying, cooking, and preserving, or than their vegetable acids. The influence of these agents in warding off or curing scurvy, may be of a catalytic nature, fitting by their presence the organic matter otherwise injurious or defective, for nutrition, in the same manner for instance as sodium chloride, which does not participate essentially by its elements in the formation of the solids and semi-solids of the body, yet is indispensable in the fixation of new proximate principles in those tissues.

Dr. Aldridge[2] held that the cause of scurvy was a deficiency in the supply of mineral matter, phosphorus, sulphur, lime, potassa, and soda; the daily

[1] Monthly Journal of Medical Science, Aug. 1847.
[2] Value of Food, Dublin, 1847.

waste of sulphur is calculated to be about 20 grains, and that of potassa and soda 80 grains in an adult of 150 lbs. (10 stone) weight. The quantity of cereals that would supply the waste of other elements of the body during a single day, can supply only 17 grains of sulphur and 43 grains of the alkalies; and a similar amount of leguminous material would give only 11 grains of sulphur and 55 of the alkalies. Succulent vegetables, on the other hand, while deficient in nitrogen and the other elements, contain mineral matter in abundance. The potato contains both organic and inorganic principles in just proportion to compensate for the necessary waste. Dr. Garrod,[1] of Edinburgh, upon the strength of one inconclusive blood analysis, declared that scurvy was caused by the use of food deficient in the potassium salts, the essential change in the blood in that disease being brought about by the insufficient supply of these salts. Neither of these views, though ingenious and plausible, has received the confirmation of scientific research.

Some of the old writers, Sennertus,[2] Charleton,[3] and Hoffmann,[4] from observing the wide-spread character of the disease, its destructive effects and extension in communities and aggregations of individuals, and its seizure of nursing infants, adopted the idea that it was contagious, or of a miasmatic character, depending upon a specific poison, just as syphilis, smallpox, or malarial diseases. M. Villemin,[5] in August, 1874, presented to the Academy of Medicine at Paris, a memoir in which he endeavored to sustain the theory that scurvy was "une maladie endémo-épidémique, contagieuse, analogue au typhus, à la peste, et résultant d'un miasme particulier." Rottwil[6] has also expressed similar views.

Morbid Anatomy of Scurvy.

After death, the body of a patient dead of scurvy presents slight evidence of *rigor mortis*, and is generally emaciated, especially when little food has been attainable, or when from the condition of the gums and teeth it could not be masticated and swallowed. Under reverse circumstances the body may retain its rotundity and fulness. It is prone to rapid decomposition, and the skin is of a dirty-yellowish or clay color, dry and parchment-like, more or less scaly and rough, and marked by bluish or livid spots of the most varying size and figure. The small and round spots located at the roots of the hair, from one to two lines in diameter, are caused by blood extravasated from the vascular network around the hair follicles, beneath the *cuticle*. The larger and more irregular discolorations are located in the deeper layers of the *cutis*. The *subcutaneous connective tissue* is more or less œdematous and infiltrated with blood, or fibrinous material tinged with blood. The bloody extravasations form swellings of a doughy feel, without well-defined limitations, unless circumscribed by resisting fasciæ; the fibrinous effusions, on the other hand, present themselves as layers from one to two lines in thickness, at first gelatinous and of a pale yellow color, but subsequently assuming a higher organization, becoming vascular, of a bright yellowish-red color, firm and even elastic to the feel, and with clearly defined outlines. The material becomes so intimately blended with the connective tissue as to destroy all appearance of its fibrillary structure. These appearances also occur in the connective tissue of the muscles, and beneath the fasciæ forming their sheaths, lacerating their fibres or softening them to such a degree that they easily

[1] Monthly Journal of Med. Science, 1848.
[2] Med. pract., lib. iii. pars v. sec. ii. cap. iii.
[3] De scorbuto, 1672.
[4] Medicina rationalis systematica, 1739.
[5] Archives Gén. de Médecine, t. ii. 1874.
[6] Nassauischen Jahrbücher, Bd. xvi. s. 749.

break down between the fingers. These deposits most commonly show themselves about the muscles of the hams, but are occasionally found in the recti and pectoral muscles of the trunk, or about the elbows, and beneath the pterygoid muscles of the face. In the severest forms of the disease, effusions occur beneath the *periosteum*, forming nodes of more or less firmness, which may lead to necrosis of the bone.

The *joints* are the seat of serous, and occasionally of sanguineous, effusions; the synovial membranes have been found eroded, the articular cartilages softened and separated from their subjacent connections, and even, in extreme cases, the bone itself may be softened and infiltrated with blood. The joints may also be secondarily involved by changes going on in the surrounding connective tissue. Morbid changes frequently occur in the *serous membranes*. The pericardium usually contains a little clear serosity; not infrequently its surface is softened, and its tissue easily lacerable, or, as in some cases, inflamed and the seat of considerable hemorrhagic effusion. The pleural cavities often contain serous fluid, and are sometimes the seat of copious bloody effusions; their walls are tinged with ecchymotic discoloration, and show indications of inflammatory action.

The most constant, indeed ever-present, changes, are found in the mouth, and constitute what is known as *scorbutic stomatitis.* The gums are livid and swollen, and separated from the teeth, which they wholly or partially conceal in their fungoid exuberance; they display an advanced stage of fatty degeneration, the tissue under the microscope presenting an abundant epithelial proliferation, and an enormous production of fatty globules. The teeth themselves are either loosened, or have already fallen out. The nasal, pharyngeal, laryngeal and bronchial mucous membranes are generally pale, and marked with flecks of dark red color, and there is present more or less bloody, turbid fluid. Œdema of the glottis is occasionally met with.

The *nervous system* is perhaps least frequently affected, yet, occasionally, the ventricles of the brain, when opened, reveal the presence of serous or sanguino-serous fluid, and similar fluids are more often found in the arachnoid. The brain itself is usually pale in color, and its vessels collapsed and empty. On the other hand, some cases display a different state of things; the brain is engorged with blood, and is the seat of extravasation, and in rare cases of softening.

The *heart* is found relaxed and flabby; its tissue lacerable and atrophied; its cavities quite empty in some cases, and in others filled with dark fluid blood. The semilunar valves lose their elasticity and fail to close the orifices accurately, so that water injected by the aorta runs freely into the left ventricle. The cardiac walls present a yellowish tint on section, and are often the seat of effusions. In cases in which the disease has been of short duration, the blood is of a dark color, sometimes fluid or loosely coagulated, while at other times it is very firmly clotted; in prolonged cases, on the other hand, the blood is usually of a lighter color, and more uniformly fluid, yet firm coagula are by no means uncommon in these cases, as noticed by Rouppe, Andral,[1] Fauvel, and others. The older coagula are thick, elastic, and closely adherent to the inner surface of the heart, but gradually merge into more recent, looser, and reddish depositions. The tissue of the heart becomes altered, the muscular fibres undergoing granular and fatty degeneration, so that at points the sarcous elements are entirely replaced by the new material. The endocardium and the inner surface of the great vessels show the evidences of sanguineous imbibition. The arterial and capillary walls exhibit no signs of marked change; Lasègue and Le Groux examined the capillaries in several

[1] Archives Générales de Médecine, 1847.

cases of scurvy which proved fatal in the siege of Paris in 1871, and found nothing, with the exception of scattered fatty granulations in their walls.[1] Analogous changes to those found in the cardiac muscles, also occur in the muscular structures of other localities. According to Leven,[2] the first muscles to undergo fatty degeneration are those of the loins; in one of his cases, the fibres of the sacro-lumbar muscles had completely lost their striation, and the sarcolemma had in great part disappeared; there remained widely separated, longitudinal lines, with the intervals crowded with granular and fatty matter. The muscles of the calf of the leg showed the same advanced changes, while those of the thigh were less altered.

The *lungs* present as varying changes as those in the heart. They may be collapsed and bloodless, but as a rule are infiltrated with bloody serosity, particularly in those cases which during life showed large amounts of albumen in the urine; ecchymoses on the surface of the lungs are not uncommon, and they are usually quite superficial. The posterior portions of these organs often show indications of hypostatic congestion or hepatization, and occasionally of gangrene. In the latter case, the gangrenous tissue breaks down easily under the finger into a pulp which emits an offensive odor. A fibrinous and bloody exudation is also found in various parts of the lungs, chiefly inferiorly and posteriorly. The bronchial mucous membrane is more or less maculated, and contains a bloody mucosity; and the same is true of the trachea and larynx.

The *digestive system* is seldom or never free from post-mortem changes. The mucous membrane of the *stomach* and *small intestine* is often softened and thickened; in places ulcerated, even to the depth of the muscular layers, the edges of the ulcers being everted and infiltrated with blood; and Dr. Ritchie finds the solitary glands in the lower part of the ileum enlarged. Similar lesions are found in the *large intestines*, and in some places, beneath a dark-red, pulpy material, easily removable by wiping, the subjacent tissues are found softened, infiltrated, or even destroyed. In other cases extensive follicular ulceration is seen, of a rounded shape, and with infiltrated borders. The entire length of the gastro-intestinal mucous membrane is more or less stippled with sanguineous effusions, varying from a pink to a blackish-green tinge, and blood in greater or less quantity is poured out into the canal.

The *liver* always presents more or less evidence of fatty degeneration; it is sometimes enlarged, gorged with dark blood, and softened, with its surface marked with spots of hemorrhagic infiltrations. The *spleen* is occasionally found of greater magnitude than natural, filled with grumous blood, its surface discolored, and its structure lacerable. Or it may be the seat of wedge-shaped infarctions. Vernette found the spleen enlarged in only 8 out of 500 cases of scurvy. The *pancreas* presents also occasional evidence of hemorrhagic effusion and softening.

The *kidneys*, although there may have been albumen in the urine during life, are usually found unaltered. Dr. Himmelstiern has observed, in a few cases, a yellowish-red layer upon the mucous membrane of the pelves and ureters, and Heyfelder reports having found the kidneys engorged with blood, and the lining membrane of the pelves, ureters, and bladder, here and there covered with bloody mucus. In those cases in which the urine during life had contained large quantities of albumen, and which had been complicated with dropsy, the kidneys presented the ordinary parenchymatous degenerations found in Bright's disease. Opitz, in prolonged cases of scurvy, has seen atrophy of the kidneys. The renal capsule is ecchymosed at points, and Cajka has reported in some cases the presence of small infarctions in the cor-

[1] Archives Gén. de Médecine, Déc. 1871.

[2] Leven, Une épidémie de Scorbut, 1862.

tical substance, and less often in the deeper structures. The pelvic, ureteric, and vesical mucous membranes present not infrequently spots of hemorrhagic discoloration, as well as of softening and erosion, and the contained urine is tinged with blood.

Pathology of Scurvy.

Hoffman, Boerhave, Huxham, Lind, and many others of the older observers, recorded their opinion that in the blood were to be sought the essential changes upon which the scorbutic phenomena depended, and they generally considered the nature of these changes to consist in a breaking down of the blood-corpuscles, or a dissolved condition of the blood, which in turn led to the sanguineous effusions so common in scurvy; a theory that had currency for many years, until chemical research finally dissipated the unfounded assertions on which it was based, and led to the establishment of more correct views. We still, however, have to deplore the fact that though much error has thus been removed, yet few new truths have been established by these investigations. The analyses are, as yet, too discrepant and too few in number to determine with precision the exact nature of the chemical alterations in the blood. The disease has happily become so infrequent that few opportunities now present themselves for chemical examination, and rarely can the quantity of blood necessary for the purpose be obtained, with safety, by venesection, in this class of patients. The want of uniformity, and the difficulties inherent to the process, as well as the varying conditions under which the analyses have been made, have contributed in no small degree to the discrepant results which have hitherto been obtained.

The frequent effusions of blood in scurvy led Andral to suspect that the chief factor in scorbutic blood was the decrease of *fibrin*, which was in perfect accord with a theory that he had formed that this change was the uniform cause of passive hemorrhage.

Magendie had already given experimental support to this conjecture, by inducing in animals phenomena analogous to those of scurvy, by the injection into the veins of defibrinated blood, or alkaline solutions. Andral[1] believed his views confirmed when in 1841 he analyzed on two occasions the blood of scorbutic patients, and found the fibrin reduced to 1.6 parts per thousand. Similar results were obtained by Eckstein and Frémy. On the other hand, the blood was analyzed by Mr. Busk, about the same time, in three well-marked cases of scurvy that occurred on the "Dreadnought" Hospital-ship, and in all of them the fibrin was in excess of the normal amount, the least being 4.5, and the greatest 6.5 parts per thousand. In perfect accord with Busk's results, were the analyses of the blood of five scorbutic females, communicated in a note to the Academy of Sciences, in 1847, by Becquerel and Rodier. In no case was the fibrin diminished, but in some it was sensibly increased. In a subsequent case, Andral found that the fibrin, instead of being less, exceeded the physiological mean, reaching 4.4 parts, and he concluded that a diminution of this element was not a necessary and constant occurrence, but only an effect, a result of prior morbid modifications, and a consequence which was produced more or less frequently according to the severity and duration of the disease. Parmentier and Déyeux found the blood of three scorbutics to resemble inflammatory blood, in respect to fibrin, while Frick obtained in one analysis 7.6 parts of fibrin, and Leven 4.3 parts.

In mild cases of scurvy, neither the color, the alkalinity, nor the coagula-

[1] Essai d'hématologie pathologique.

bility of the blood differs from that of blood in health, though Wood alleges that the clot is loose and cotton-like, and Canstatt that its coagulability, in consequence of the large proportion of saline matters, is diminished. In Busk's cases, the separation of the clot and serum was as perfect, and took place as rapidly, as in healthy blood, and in two of them the blood was both buffed and cupped, as it was also in Leven's cases. In two of the most severe of Becquerel's cases the blood coagulated firmly, and in a slight case the clot was dark and loose. The *albumen* of the blood shows no marked change as regards its quantity. The five analyses of Becquerel and Rodier showed the average amount of organic matters of the serum to be 64.3 parts in a thousand, the smallest being 56.2 and the largest 69.2 parts. One thousand parts of the serum of the same cases gave an average of 72.1 parts of organic matter. Frick's single case gave 87.045 parts per thousand, and the average of Busk's was 78.2 parts, while Chotin and Bouvier obtained only 62.3 parts. The last-mentioned writers have recorded a fact in connection with the physical characters of scorbutic blood that deserves notice: the blood in one case did not coagulate at the usual temperature—about 158° F.—but required a temperature some degrees higher for that purpose. The *red corpuscles* in all the foregoing cases were notably diminished, the largest amount given being 117.078 parts per thousand, while the lowest was 47.8 parts. In Andral's second case the globules had decreased to 44.4 parts per thousand, the lowest amount yet recorded.

The alkalinity of the blood seems not to be changed, although Chotin and Bouvier notice a slight increase. The *saline* constituents do not vary greatly from the normal standard. The average amount in Becquerel and Rodier's, and Busk's, cases was 8.1 parts per thousand, the smallest being 5.5 parts and the largest 11.5. In Dr. Ritchie's two analyses, the proportion of saline matters is given as 6.44 and 6.82 parts per thousand. Opitz and Schneider have found less than the physiological mean. In Frick's case the amount was 8.8, the iron being 0.721 parts per thousand, and 0.782 to 127 parts of globules; lime 0.110, chlorides 6.846, and phosphates 1.116 parts per thousand. The iron was in excess of that in the normal blood, but in Becquerel's cases the mean was 0.381—less than the normal. The proportion of iron in Duchek's cases was respectively 0.393, 0.402, and 0.476 parts, giving a mean of 0.423 parts per thousand, which nearly approximates the normal. Garrod in one analysis of the blood found a deficiency of the potassium salts, upon which he erected his well-known theory of the etiology of the disease. It is an interesting fact that in the physiological state the quantity of sodium chloride is not subject to variation, any excess introduced with the food being thrown off by the kidneys. The quantity in the urine bears a relation to the amount introduced as food, but the proportion in the blood is constant.

The quantity of *water* in the blood has been found to be increased in all the analyses which have been made. Chotin and Bouvier estimated water and loss at 831.1; in Frick's case it was 791.69 parts per thousand; and in Becquerel's five cases it was put at 807.7, 810.9, 811, 813.7, and 854.0 parts per thousand respectively. In Busk's three cases the lowest amount was 835.9, and the highest 849.9 parts per thousand. The *specific gravity* of the defibrinated blood was in all cases low in comparison with the normal standard, 1057, the average in Becquerel and Rodier's cases being 1047.2, the lowest 1038.3, and the highest 1051.7. In the single observation of Chotin and Bouvier it was 1060. The specific gravity of the serum was also less than normal (1027), the average of four of Becquerel's analyses giving 1023.8, the lowest 1020.8 and the highest 1025.5. Busk gives 1025 in one case and 1028 in another.

The results of the most recent analyses, those of Chalvet, are shown in the

following table, in which scorbutic blood is contrasted with that of a healthy robust female:—

	Scorbutic Blood.	Healthy Blood.
Water	848.492	779.225
Solid matters	151.508	220.775
Dry clot	140.194	209.000
Albumen	72.304	68.717
Fibrin	4.342	2.162
Globules	63.548	138.121
Extractive matter—by absolute alcohol	10.312	8.013
by ether	1.002	1.300
Ashes of clot	3.000	5.691
Peroxide of iron of globules	1.060	2.259
Potassium of globules	0.329	0.625

From the conflicting statements of the various observers, the following conclusions may be formed: That in scorbutic blood, water is in excess; that there is on the one hand a marked increase of the fibrin, and in a less degree of the albumen and extractive matters, while on the other hand there is a marked decrease of the globules, and in a less degree of the mineral matters. On the authority of Chalvet, it may also be stated that demineralization of the muscular tissue is a notable chemical feature in scurvy.

So far, microscopic examination has been entirely negative. Hayem[1] found no appreciable alteration from healthy blood, and in this view Leven[2] concurs; while Laboulbène[3] notes the occurrence of an unusual number of white globules.

Symptoms of Scurvy.

The symptoms of scurvy are insidiously, and usually slowly, developed under the influence of the efficient causes, and it runs a chronic course, often extending over six or seven months, especially in cases in which the hygienic surroundings of the patient have been imperfectly or not at all rectified. In lighter cases this course is much shorter. A gradual alteration of the nutritive processes first occurs, until what might be called a *scorbutic cachexia* is established, in a period varying from a few weeks to several months. The initial symptoms consist in the *skin* losing its color and tone, and assuming a yellowish or earthy hue; it is relaxed, dry, unperspiring, and rough; in the legs, particularly, this roughness is very marked, and the skin, when rubbed, sheds an abundance of furfuraceous scales. The cutaneous follicles, markedly on the extensor aspect of the lower extremity, are prominent, similar in appearance and feel to the condition known as "goose flesh." Rouppe[4] calls this the *signum primum pathognomonicum.* Dark-red or brownish flecks, of a circular outline, and of varying but small size, not unlike flea-bites, appear on the face and limbs. The cutaneous circulation is feeble, and the superficial warmth less than natural; slight depression of the atmospheric temperature produces a sensation of chilliness, and the feet and hands are cold. On assuming the erect posture, the patient complains of headache and dizziness. The *muscles* are relaxed, and soft to the feel, and a corresponding loss of vigor and strength is experienced by the patient, who is indisposed to exert himself in the performance of his customary duties, and seeks repose and freedom from feelings of fatigue and languor in recumbency. This prostration is occasionally so extreme that the slightest efforts in attempting to stand or walk are attended with rapid action of the heart, accelerated respiratory

[1] Mém. de la Société de Biologie.
[2] Epidémie de Scorbut.
[3] Communication to the Académie des Sciences, 1871.
[4] De morbis navigantium.

movements, and a sense of suffocation or breathlessness. The general *circulation* is impaired; the heart acts feebly; the arteries are contracted; and the pulse is slow, small, and compressible.

The *mental powers* are equally impaired. The face wears a haggard and depressed expression; gloomy forebodings of the future, and disinclination to turn the attention to the usual mental pursuits, are markedly present—a disinclination that subsequently merges into complete apathy or indifference to passing events, or even into somnolency.

Pains in the legs, joints, and loins, are early manifestations; they closely resemble those of rheumatism, for which they are often mistaken. The pains are not exacerbated at night, but, on the contrary, are often more severe by day. Not unfrequently, lancinating pains in the muscles of the chest are complained of. The sleep is not disturbed until the disease has made some advance, when it becomes broken, and no longer refreshing. The *appetite* is usually unimpaired in the early periods of the disease, and even throughout its course, the condition of the mouth alone preventing the patient from indulging his desire for food, even, as is occasionally noticed, to voracity. There may be a yearning for certain articles of diet, principally those of an acid character; but, on the other hand, some cases present exactly the reverse condition—a disgust for food in general, or for particular varieties; or the appetite may be vacillating, at one time craving, and at another repelling nourishment. There is no noticeable change in the normal thirst, unless on the occurrence of febrile complications, when it is increased. The *gums* do not, at this stage of the disease, present the livid, swollen appearance of fully-developed scurvy, but, on the contrary, are generally paler than usual, with a slightly tumid or everted line on their free margins, and are slightly tender on pressure. The breath is commonly offensive, and the patient complains of a bad taste in the mouth. The *tongue* is flabby and large, though clean and pale, and the bowels are inclined to be sluggish.

This preliminary state is followed, after varying intervals of time, by certain local phenomena which are quite characteristic of the disease. There is a marked tendency to *extravasation of blood* into the tissues, either spontaneously or upon the infliction of slight injuries or wounds. *Fibrinous* exudations occur sooner or later into the gums, which become darkened in color, inflamed, swollen, spongy, and which bleed upon the slightest touch, finally separating from the teeth. These results are due in part to the considerable amount of pressure to which these parts are subject in mastication, and it is a conspicuous fact that the gums of edentulous jaws remain free from these changes. In a few cases the gums are but slightly altered, perhaps œdematous only, or pitting upon pressure; or they become the site of bloody extravasations. In severer examples, in later stages of the disease, these various alterations progress to an extreme degree, and the extravasation is so voluminous that the gums present great, fungous, lacerable excrescences, which may finally break down into a suppurating, brownish, and very fetid mass, which communicates to the breath an odor of a most offensive character. The rest of the mucous membrane of the mouth remains unaltered, or at most slightly ecchymotic. Samson and Charpentier,[1] in a large number of cases saw this but once, and in one of Leven's[2] cases the fungous growth invaded the palatal mucous membrane, extending to the anterior pillars of the fauces. The salivary glands are enlarged and swollen; the tongue is imprinted with the form of the teeth, while the latter become encrusted with tartar, and more or less concealed by the exuberant gums, or, becoming gradually loosened from the alveoli, finally drop out. The morbid process may even extend to the bone

[1] Étude sur le Scorbut, 1871.

[2] Une épidémie de Scorbut, p. 28, 1872.

itself, and necrosis and extensive exfoliation may follow. Mastication is more or less painful, and often impossible, so that the patient is reduced to the necessity of prolonging life by the use of fluid or semi-solid food. Under the influence of appropriate treatment, it is remarkable how rapidly (in from two to four weeks) these marked changes recede, and the parts resume their normal condition; yet it occasionally occurs that permanent, callous thickening of the gums results.

In the progress of the disease, *effusions of blood* under the skin are of early occurrence. They are at first located in the superficial stratum of the cutis, or just beneath the epidermis, especially around the roots of the hair; and present themselves as roundish, bluish-red flecks, varying in size from that of a pin's-head to that of a split pea, not effaceable by pressure with the tip of the finger, but slightly, if at all, elevated above the surface, and enduring for weeks together. The nutrition of the hair-follicles is impaired, so that the hairs are often either lost, broken, or distorted. These petechiæ fade in color with progressive improvement in the case, and finally disappear, leaving behind brownish-yellow discolorations. They first appear in the extremities, particularly the lower limbs, then in the face, and lastly in the trunk. At a later period, extravasations of a larger size and more irregular form occur in the deeper layers of the derma. They vary in size from that of a finger-nail to blotches two or three inches in diameter; at first reddish in color, and subsequently of a bluish-red. When recession occurs, under appropriate treatment, the color passes through various shades of violet, blue, green, and yellow, as in ordinary traumatic ecchymoses. Outpourings of blood also occur into the subcutaneous connective tissue, notably that of the legs, and in localities where connective tissue is particularly abundant and loose, as in the ham and axilla. The dispersion of blood in this tissue may be so considerable as to cause the legs from the knees down to present a uniform, dark-blue coloration, that in form may not inaptly be compared to a stocking. The upper extremities also suffer, usually on their inner side, from the armpit down, the extravasation rarely reaching, however, to the hand. These extravasations take place also after the infliction of very slight injuries, as from blows, or the pressure of hard bodies, or even from the mechanical effects of prolonged dependency of the limbs, as in riding on horseback. Extravasations of a similar nature are occasionally present in the connective tissues of the muscles themselves, or between them, giving rise to swellings of various forms and dimensions. Nearly always, along with the sanguineous effusions, there is more or less *œdema*, usually beginning at the ankles, and gradually extending upwards; in some cases, there are puffiness of the face and general anasarca, so that deep pits remain on pressure.

This profound impairment of nutrition of the skin continuing, in the worst cases blood is effused beneath the cuticle, forming blebs of varying size, which finally break and leave superficial, ulcerated surfaces, which ultimately become covered with flabby, exuberant granulations, pouring out a purulent, often offensive sanies, and bleeding upon the slightest touch. In some cases the ulceration begins in the petechiæ at the hair-roots, and a number of these running together form a large ulcer. The destruction of tissue by ulceration is disposed to spread more widely and deeply, and is often of a most intractable character. Old cicatrices are the first tissues in these cases to take on the ulcerative action. Certain muscles, chiefly those of the legs, and notably the gastrocnemii, the abdominal and pectoral muscles, the psoas magnus, and the pterygoids, may become the seat of fibrinous extravasations, which finally change, by lapse of time, into hard, firm tumors, impairing the functions of those parts, and leading to contractions of the limbs.

The symptoms in certain epidemics of extraordinary severity, have dis-

played alterations in still deeper structures. Effusions occur between the *periosteum* and the *bone*, forming painful, hard, and resisting nodes of varying dimensions, especially along the course of the tibiæ, upon the scapulæ, and upon the maxillæ. In young persons the epiphyses are separated from the shafts of the long bones, and in other cases the ribs become necrosed and disarticulated from the sternum, producing a creaking noise during respiratory movements, as related by Poupart.[1] This occurs mostly on one side and about the middle of the series, yet it has been noted to occur on both sides, so that the sternum and attached cartilages, deprived of support, were perceptibly sunken. Recently repaired fractures have been known to recur under the influence of scurvy, from destruction of the callus.[2] The *articulations* as well as the bones in very severe cases of scurvy present evidences of disease, consisting in periarticular effusions which involve the surrounding soft parts, producing impairment of motion, enlargement, and false anchylosis, and even destroying the normal anatomical relation of the osseous surfaces so as to determine deformities. These changes are usually attended with severe pain, and most commonly occur in the ankle, knee, shoulder and hip joints, and disappear tardily, requiring perhaps months for their recession, if indeed this takes place at all.

The symptoms manifested by the *circulatory organs* are prominent from an early period of the disease. The pulsations of the heart are slower, feebler, irregular, and often intermittent; its impulse is decreased, or becomes quite imperceptible; and when the associated anæmia has progressed to a certain extent, a systolic murmur may be audible. The arterial and venous channels are of diminished calibre; the pulse becomes soft, of less volume, and tardier; and a venous murmur may sometimes be heard in the cervical veins. The remarkable nutritive changes in the capillary walls, in part account for the numerous *hemorrhages* which occur both by rhexis and diapedesis. The most frequent is epistaxis; the slightest blows, sneezing, or blowing the nose, will often determine it, or it may occur spontaneously, and in severer cases with such profuseness as to threaten impending dissolution, requiring nothing less than timeous introduction of the tampon to rescue the victim. Hemorrhage from the lungs is of rare occurrence, and when it does occur is rather indicative of pre-existing pulmonary disease, such as phthisis, or of the approach of a complication such as an infarction or gangrene, than a constituent feature of scurvy. Hæmatemesis is less uncommon, but is by no means frequent; the blood ejected from the stomach is usually limited in quantity, but in isolated examples the bleeding is profuse, producing great exhaustion and a sense of cardiac depression which preludes speedy death. Hemorrhage from the bowels is also an ill-omened feature, completely blanching the patient, and presaging early exhaustion and death. Blood may also appear as a product of a complicating dysentery which determines abundant, offensive discharges that may run on for several weeks before the patient is finally exhausted. Hæmaturia sometimes occurs, especially in broken-down and cachectic subjects, and in an advanced stage of scurvy. All of these forms of hemorrhagic effusion, now mentioned as localized in the mucous membranes, are to be deprecated as exercising a pernicious influence, seriously aggravating ordinary cases, and fatally jeopardizing the issue of severe ones.

Effusive and inflammatory complications are also encountered in the *serous structures*, and usually in cases of great severity, though they occasionally present themselves when the more common localized phenomena of scurvy are not particularly prominent. These complications may be marked by a

[1] Mémoires de l'Académie des Sciences, p. 237, 1699; and Philosophical Transactions, vol. xv.
[2] Anson's Voyage around the World, edited by Walter.

gradual accession, or they may rapidly arise and involve the patient, just before in apparent security, in the greatest peril. These incursions are almost always attended by febrile exacerbations, and the usual grouping of clinical characters denotive of the same pathological conditions arising under ordinary circumstances. The local complications may either affect the pleura or pericardium, or both. In Dr. Karawajew's[1] sixty autopsic examinations, pericardial effusions were noticed in thirty, pleural in thirty, pericardial and pleural in six, peritoneal in seven, and arachnoideal in only one. The exudations are sero-sanguinolent or fibrinous in character, and sometimes reach the inordinate quantity of four or five pounds, occasioning the patient the utmost distress, and embarrassing the respiratory and circulatory functions. Although these augment in a high degree the risk to life, yet under prompt and appropriate treatment recovery may take place, and the effusions vanish with surprising rapidity.

Hemorrhagic extravasation into the *nervous centres* is a very rare occurrence. It has not been as yet recorded as having occurred in the brain-substance itself, but has in several instances been noted between the meninges, producing headache, dizziness, vertigo and finally somnolence, delirium, and coma. Opitz[2] relates an interesting case in which convulsions suddenly occurred with unconsciousness, followed by hemiplegia of the left side of the body and the corresponding side of the face. After twenty-four hours, consciousness returned and the paralysis had disappeared. There were however headache and hyperæsthesia of the upper extremities present; twelve days later these also receded, and the patient finally recovered. The same author records paralysis as occurring in one case from extravasation into the spinal meninges. Dr. Samson observed an instance in which a fibrinous effusion formed upon the sciatic nerve, with consequent pain. In the circulatory system, symptoms always of threatening and often of fatal import arise; *embolism* may occur at various points, particularly in the lungs and spleen, occasioning hemorrhagic infarctions which have undoubtedly been the occasion of the sudden deaths sometimes observed in scorbutic cases not apparently of a very dangerous form, nor attended with an excessive degree of exhaustion.

The *urinary system* supplies no prominent symptoms; the statements as to the condition of the kidneys and the composition of the urine are contradictory. The urine not unfrequently contains albumen, particularly in severe cases, but this is by no means indicative of corresponding changes in the renal structure; on the contrary, this may be found after death to be apparently free from disease. Simon[3] examined the urine in three well-marked cases of scurvy occurring in Schönlein's wards; two were men between thirty and forty years of age, and the third a woman who had been delivered a few days previously. In its physical characters the urine was very similar in the three cases; at first it was very scanty (8 to 12 oz.), and of a dark-brown color, as if bile pigment or decomposed blood were present, which, however, was not the case. It was devoid of the peculiar sweetish odor of typhus urine, but, after standing a few hours, developed a disagreeable ammoniacal odor. There was a deficiency of the phosphates, and the amount of urea was much less than in normal urine, not exceeding 20–30 per cent. of the solid residue.

The fixed salts were diminished in the urine of the men, forming 14–18 per cent. of the solid residue, while in the woman they amounted to 27 per cent., a little above the normal average (25 per cent.). The uric acid was slightly above the healthy standard in all the cases, forming 1–3 per cent. of the solid residue.

[1] Himmelstiern, Beobachtungen über den Scorbut, S. 50. Berlin, 1843.
[2] Prag. Vierteljahrsschrift, S. 153, 1861.
[3] Chemistry of Man, p. 320.

Krebel[1] states that the urine is at first cloudy and brown, afterwards becoming decomposed and offensive, and an oily scum forming upon it. Duchek[2] dissents from this statement, and asserts that in slight cases the urine in its physical properties is unaltered; and that in aggravated cases it is generally of a deeper color, somewhat decreased in quantity, as happens usually in fevers, and always of an acid reaction. The quantity is diminished to from 1200 to 1500 cubic centimetres, and in very severe cases is as low as 830 cubic centimetres; the specific gravity runs as low as 1015 to 1009, and the quantity of all the solid constituents is diminished, with the exception of phosphoric acid and potassa, the latter being in proportion to the soda as 1 to 1.9, while in health it bears the proportion of 1 to 12. As recovery progresses, the quantity of both urine and its solid constituents increases, with the exception of the potassa which, on the contrary, decreases. Chalvet's analysis of the urine, from a well-developed scorbutic subject, furnished the following result:—

Water		950.50
Solid matters		49.50
Matter soluble in absolute alcohol	Urea	9.60
	Extractive	12.60
Albuminoid matter		7.50
Mineral matter		19.50

The conclusions that would seem to be authorized by the statements of these various authorities, are that the quantity of urine passed is decreased, as well as that of the urea, while the amounts of the albuminoid and mineral matters are increased.

Physical examination will reveal the frequent occurrence of enlargement of the *spleen*, independent of malarial influences, and Krebel has encountered one case in which the *liver* was involved in inflammation. Some derangement of the *visual organs* is present in numerous cases. Dr. Foltz, in the epidemic on the Raritan, reported four cases of nyctalopia and two of hemeralopia, and other affections of the eye, such as conjunctivitis, induration and irritation of the ciliary margins of the lids, with a copious and acrimonious discharge, these conditions being obviously due to the scorbutic diathesis. Hemorrhage may occur under the conjunctiva, raising it into small pouches; into the anterior chamber, causing iritis and adhesions; and finally into the choroid and vitreous humor, exciting a general inflammation of the entire organ. Dulness of hearing and buzzing in the *ears* have also been signalized as occasional symptoms of scurvy.

The phenomena of *fever* are always absent during the course of uncomplicated scurvy, the temperature of the mouth sometimes falling as low as 92° F.; and being always one or two degrees lower than normal. It is only in the later periods of the disease, when pathological processes most often supervene in the internal organs, that an elevated temperature and the other ordinary symptoms of fever are manifested. The lowered vital resistance of scorbutic subjects particularly disposes them to the incursions of other fevers, especially those of malarial and typhoid types; hence in the low, marshy districts of northern Europe, and in sections of country afflicted by famine and overcrowded dwellings, these complications are very common.

[1] Der Scorbut, S. 156.

[2] Zeitschrift der k. k. Gesellschaft der Aerzte zu Wien, Bd. i. S. 56.

Diagnosis of Scurvy.

The recognition of scurvy is not surrounded by any embarrassing difficulties, as its exclusive etiological character, the altogether special circumstances of its occurrence, the peculiar location of the disease in the various tissues, and the establishment of the preliminary cachexia, with the peculiar dull, earthy hue which subsequently merges as it advances into a deeper and cyanotic tint, point with unerring certainty to its identification. It is rarely restricted to isolated cases, but invades groups of individuals, or communities living under similar or identical hygienic conditions, as occurs on board ships, in prisons, in armies, in places closed by siege, or in districts of country afflicted with common calamities. Single cases are, however, occasionally met with, and I have myself observed one, in the person of a man who from penurious motives had abstained from all but the cheapest and coarsest articles of diet, subsisting chiefly on refuse food of an animal character, purchased in the markets and made up into soups. The disease was at first supposed to be purpura hæmorrhagica, until the above mentioned facts were discovered and a closer inspection made of the variously colored spots; the persistent and severe pains in the limbs and back, the swollen joints, ulcerated gums and fetid breath, then led to a correct conclusion, and the man soon recovered under dietetic treatment. The same conditions, in individual cases, will enable the observer to make a correct discrimination of scurvy from other pathological states involving hemorrhagic extravasations into the tissues, such as occasionally occur in anæmia, chlorosis, leucocythæmia, pseudo-leucæmia, pernicious anæmia, and hæmophilia. These never occur except in isolated instances, while scurvy, as stated before, is rarely seen except as afflicting numerous persons at the same time. In the former diseases, also, the gums never present, although they may be tender and disposed to bleed, the peculiar color and sponginess characteristic of scurvy. An error might, however, creep in here if we were to depend solely upon this phenomenon, for cases of scurvy have been reported in which this condition did not exist, and it does not occur, as already remarked, in edentulous persons. The state of the gums in leucocythæmia, it has been said, occasionally approximates this condition, but the other associated symptoms would suffice to differentiate that disease from scurvy.

The rapid improvement of scurvy under fresh vegetable diet, will also present a striking feature not encountered in anæmic and purpuric cases. In the commencement of an outbreak, the rheumatoid pains, so common in the back and limbs in the severe cases, have caused them to be confounded with rheumatism; inquiries into the condition of the gums and skin will readily dispel this error.

Finally, in none of the diseases with which it is possible to confound scurvy, do we meet with the same complications of vital organs: fibrinous and bloody effusions among the muscles, and into the pleura, pericardium, peritoneum, and synovial sacs of the joints; deformities of the limbs from contraction of tendons; and distorted joints from the plastic outpourings about them. All of these features are special to scurvy, and serve to complete a clinical picture altogether characteristic and distinctive.

Prognosis of Scurvy.

The prognosis of scurvy will depend upon the stage of the disease, its grade of intensity, its complications, the constitutional power of the patient, and the

nature of the attendant circumstances—particularly the possibility or not of changing or ameliorating the hygienic surroundings. In the earlier stage of the disease, recovery under proper treatment is assured; and it is remarkable how soon the spongy gums and discolorations of the surface will recede, and the patient regain strength and cheerfulness. Even in cases of notable intensity, unaccompanied by involvement of the internal organs or serious complication with other maladies, the prognosis is very hopeful when the patient can be put under favorable influences. Yet it must be said that often apparently slight cases do not recover as rapidly as others which are seemingly, from external appearances, much more severe. Complicated cases, with implication of the thoracic or abdominal viscera, where these conditions have entailed no considerable effusions, though more unfavorable than the preceding groups, are still amenable to well-directed therapeutic measures. The same conditions, however, linked with abundant outpourings of serum and blood into the pleural, pericardial, and abdominal cavities, are exceedingly unfavorable, and bode a mortal issue. Excessive and frequent hemorrhages are liable to bring on speedy death by syncope; epistaxis was at an early period considered a mortal sign, and one necessarily fatal. Colliquative diarrhœa and dysentery exhaust the strength rapidly, and induce a fatal issue by causing early and profound prostration, or by their continuance lead to the same result through gradual asthenia. Persons weak and feeble, either constitutionally or from the inroads of prolonged disease, especially of a malarial character, from a previous attack of scurvy, or from other cachectic complaints, are less apt to recover than those of an opposite character. The attendant circumstances have also an important influence on the prognosis. On shore it is easier to secure good accommodations, with dry, well-ventilated, and clean apartments, and abundant supplies of fresh vegetable food and other desirable forms of nourishment, than on the sea; in long voyages, or in exploring parties into the interior of unknown countries or in high latitudes, it may be impossible to control to any considerable degree these indispensable requirements for the recovery of the sick, and the outlook will be gloomy indeed for successful treatment of even the mildest cases.

Treatment of Scurvy.

There is no disease within the whole range of pathology which yields such satisfactory results to well-directed and judicious treatment as does scurvy; and this is all the more gratifying when it is remembered that, during its period of rifeness from the 14th to the 18th century, it did more destruction to armies and fleets than the sword of the enemy and the other dangers of warfare combined. Equally as remarkable results in warding off the disease attend the intelligent adoption of the prophylactic, hygienic measures which experience has shown in multitudinous instances, through a long period of time and almost everywhere, to be indispensable to the maintenance of health. A cursory consideration of these measures will be a fitting prelude to a discussion of the means which should be had recourse to in the actual invasion of the disease.

Prophylaxis.—Great ameliorations have been effected during the last century, and particularly within the last thirty years, in the physical conditions under which the sea-farer and the poor in northern climates live. Both house and ship hygiene have made advances, and the people everywhere enjoy the fruits resulting therefrom, in possessing better lodgings, greater variety of food, purer air, more comfortable clothing, and, as a necessary corollary of this, a

higher moral life and increased happiness. These circumstances have limited scurvy to a restricted prevalence on board of badly-equipped merchant vessels, in long passages; among exploring parties in high latitudes; in armies during time of war, cursed with an incompetent commissariat; and occasionally among the inhabitants of besieged towns. It has been attempted by legislation, with more or less success, to enforce on board merchant ships the adoption of the proper hygienic measures. Such laws are in force in the United States, in Great Britain, and in other countries, and require that all ships shall carry certain articles of acknowledged anti-scorbutic power, and that the quarters of the men shall possess a requisite amplitude. In the equipment of arctic vessels, proper prevision is always displayed to avert the invasion of scurvy during such service.

The greatest import attaches to an unsparing storing up of fresh vegetable and animal food, which should always be provided at the commencement of any voyage likely to be prolonged for several months. It is often possible to carry live animals for days together, and the stock may often be replenished at the different ports touched at. By the various processes of canning, preserving, drying, etc., fresh provisions of all sorts can be obtained, that may be relied on as capable of supplying good, wholesome animal food. Eggs form a most desirable article of diet, and may be kept good for months by simple methods of packing; and their nutritive value will be appreciated when it is considered that a single egg contains as much nourishment as two ounces of fresh beef. Another excellent animal food, on account of its nutritive qualities and reported efficiency as an anti-scorbutic, is milk, which, when properly prepared, can be preserved in its original purity and with undiminished nutritive value, indefinitely. Vegetable food of the most varied character can now be obtained almost anywhere, and a ship should not leave port without laying in a stock of potatoes, beets, carrots, cabbages, and fruits, which should be regularly served out as part of the ration. With a very simple contrivance, quickly growing vegetables may be successfully cultivated on shipboard. The plants most suitable for this purpose are the mustard, cress, radish, turnip, etc.; cresses and mustard are the most rapid growers. Almost as efficient representatives of these fresh products of the garden are the same articles prepared in various ways, and put up in tin and glass vessels, and when the former are not procurable these should be substituted in the ration. Sauerkraut can be kept indefinitely in any climate, and has deservedly enjoyed reputation as a good anti-scorbutic, while it is cheerfully received by the sailor in his ration. Desiccated potatoes have been found, after several years' trial in the navy, to possess neither much food value, nor to be at all palatable, and, when served out, have as a rule been thrown away, so that other preparations should be preferred. Canned tomatoes are, on the other hand, eagerly accepted, and are much esteemed by the men. Cheese and oatmeal would also be desirable additions to the ordinary allowance.

The value of lime-juice as a preventive of scurvy was long since known, yet it was not made a part of the English navy ration until 1795, when it was regularly served out. The merchant shipping act of England requires a supply to be carried by all merchant vessels, and it is ordered to be served out daily after the crew has been ten days on salt food. The juice readily undergoes change, if not prepared with the greatest caution, and particularly on exposure to the air; on this account it ought to be carried in glass receivers of from one to two gallons each, instead of casks or large vessels, so that one or two servings may exhaust the contents. Ordinarily the juice is mixed with 10 per cent. of spirit. These circumstances have rendered it desirable to have a preparation of the juice in some more concentrated and permanent form. Dr.

Lind[1] recommended a preparation of this sort, many years ago, under the name of "Rob." The very concentrated juice may also be preserved in glycerine, or in a solid form as a lozenge or biscuit. Malt, originally proposed by Dr. MacBride, on theoretic grounds, was highly esteemed by Captain Cook as a preventive, under the form of sweet wort. So, too, did he think well of the Scotch dish called "sowens," prepared by concentrating the liquid resulting from the fermentation of oatmeal. Cider is also possessed of acknowledged anti-scorbutic power.

It is a matter of importance not to fail in issuing good potable water to the crew, and fortunately this desideratum is now fully secured on war vessels by the distilling apparatus with which they are supplied. In the mercantile marine, the dependence is chiefly upon the shore supply, which should be inspected as to quality before being received. The general qualities of water as to potability may be roughly tested by an intelligent person by simple chemical means. An important adjunct in preserving health in long voyages, is a good wardrobe of clothes suitable to the sudden and severe atmospheric vicissitudes; warm woollen underclothing and stout cloth suits, for stormy weather and the cold of high latitudes. The greatest care should be exercised to avoid sleeping in wet garments, and when these have been removed, they should be dried without delay. The sleeping apartments of the crew should always be kept scrupulously clean and dry, and at the same time supplied with the requisite quantity of pure respirable air, and, if possible, abundant sunlight. It is unnecessary to do more than cursorily remark that all possible means should be adopted to sustain a cheerful disposition among the crew, encouraging the use of musical instruments, games, and social gatherings on proper occasions. Attention to the foregoing circumstances: varied diet, wholesome water, suitable clothing, and comfortable, well-ventilated quarters, will assure the utmost security against the occurrence of scurvy, either on shipboard or on the land. There is really no difference in this respect, as the same hygienic provisions apply equally to the soldier and sailor, and to the occupants of crowded eleemosynary and penal establishments.

Curative Treatment.—In the management of the disease therapeutically, the first consideration is to amend the diet, if possible, supplying fresh meats, soups, or other nitrogenous food in a readily assimilable form, and recent vegetables; the chief of the domesticated varieties of these are cabbages, beets, radishes, turnips, carrots, and potatoes; others, growing wild, are sorrel, cresses, taraxacum, nasturtium, mushrooms, garlic, mustard, scurvy and common grass, and the tops of the spruce. These are attainable almost everywhere, and some even in the hyperborean regions. The ancient Celt used the common shamrock as food. The useful fruits are those of an acescent character, and the juices of the lime, lemon, and orange, hold deservedly the first rank. When these are not attainable, apples, pears, grapes, cherries, and currants will be of decided advantage. The vegetable acids, citric, tartaric, and acetic, their combinations with potassium, and the acescent wines will be of service. Dr. Perin[2] found in his experience the expressed juice of the Maguey, or Agave Americana, superior to all other anti-scorbutic remedies, not excepting lime-juice. Nitrate of potassium, either alone or mixed with vinegar, has been lauded as an anti-scorbutic. It is remarkable how rapidly the most painful and even threatening symptoms melt away, as it were by magic, under this dietetic treatment alone. In cases associated with debility, or tardy in convalescence, the bitter and aromatic tonics, quinine, gentian, etc., either alone or combined with ferruginous preparations, and the mineral acids, will be

[1] Treatise on the Scurvy.

[2] Medical Statistics, U. S. Army, 1839–54, p. 362.

indicated, as well as beer and wine. Derblich[1] records his belief that the tincture of cantharides exercises almost specific effects in the treatment of scurvy.

In meeting complications, appropriate remedies will be found for the scorbutic *stomatitis* in the mineral and vegetable astringents, washes containing carbolic acid, and solutions of chlorinated lime or permanganate of potassium; a solution of nitrate of silver also yields good results. These various remedies will afford relief, but no permanent improvement will ensue without the consentaneous adoption of vegetable food. The alterations in the *skin* demand no particular treatment, unless ulceration has occurred, when the use of soothing applications, and protection from sources of external irritation, will be indicated; while at the same time the parts must be kept perfectly clean and free from offensive odor by the use of chlorinated or carbolated washes. In the hemorrhagic complications, the same treatment will be indicated as in similar conditions unaccompanied by scurvy. Epistaxis may be checked by cold applications to the head, and by making the patient snuff astringent powders, such as tannin, powdered rhatany, etc. In serious cases, plugging of the nares must be promptly adopted. Hemorrhage from the stomach or bowels is to be checked by the external use of cold cloths, or ice, to the abdomen, and by the internal administration of ergot, tincture of the chloride of iron, gallic acid, acetate of lead and opium, or other agents of the hæmostatic class. Effusions of blood or sero-sanguinolent fluid into the pericardium or pleura, if not excessive, will generally recede as the general condition improves under the treatment already indicated. Should the quantity, however, increase to such a degree as to embarrass the circulation and respiration, there is no alternative left but paracentesis, which at most affords slender chances for recovery.

In the management of this disease, an important indication is to have the patient so watched that he may not be permitted to perform any movement likely to throw an additional burthen upon an already overtaxed heart; it has happened, time and again, that assuming the erect posture suddenly, or ascending a few steps, has resulted in immediate death. The strength must be taxed neither by active catharsis nor by bloodletting; should the bowels need moving, the gentlest laxatives will suffice to secure the desired effect. All preparations of mercury should be avoided, as they exercise the most pernicious effects, especially when carried to the extent of salivation. The evil results of these remedies were lamentably shown in the wholesale slaughter of four hundred men as reported by Kramer.

[1] Wiener medizinische Wochenscrift, 1861, S. 827.

THE RECIPROCAL EFFECTS OF CONSTITUTIONAL CONDITIONS AND INJURIES.

BY

A. VERNEUIL, M.D.,

PROFESSOR OF CLINICAL SURGERY IN THE FACULTY OF MEDICINE, PARIS.

It is yet very difficult to establish in an exact and complete manner the relations existing between constitutional conditions and traumatic lesions, but even now, by the aid of the literature hitherto collected, we have (1) acquired very useful ideas in regard to the diagnosis, prognosis, and treatment of injuries which occur as the results of surgical or accidental wounds, and (2) formulated much more distinctly the indications and contra-indications for operation in individuals affected by previously existing constitutional states. If we consider how much has already been done in this direction, despite the short time since these studies have been begun, and the very small number of authors who have investigated them, we may be assured that they will render, before the end of the present century, considerable service to medical science and to the art of surgery. Before entering directly into this question, it will be useful to define what I mean by constitutional diseases, and to indicate their number and their classification.

A constitutional disease, clearly represented by the old expression *morbus totius substantiæ*, and which may be more concisely termed *panpathy;* a constitutional disease, I say, affects at the same time all the organic fluids and solids, altering the latter more than the former, or *vice versa ;* modifying by preference this fluid, or affecting this system, rather than others; but at a given moment involving the entire economy. The number of these diseases has been sometimes too much restricted, sometimes too much extended, and a reform must be attempted in this respect. I shall content myself with drawing up a list into which may enter all those which are already known, or which are yet to be recognized.

(1) *Diseases of nutrition*, usually hereditary, but also acquired: arthritism (including gout and rheumatism); undoubtedly cancer; scrofula (including the large majority of cases of tuberculosis).

(2) *Poisons of external origin:* syphilis, malaria, alcoholism, morphinism, saturnism [lead poisoning], glanders, heterochthonous septicæmias; or *of internal origin:* diabetes, leukæmia, autochthonous septicæmias.

(3) *General conditions following sooner or later on a permanent lesion of an important viscus*, such as the lungs, heart, liver, kidneys, brain, spinal cord, etc. Although presenting the fundamental characteristics of constitutional diseases, these conditions have not yet received a special name. It is only

recently that those suffering from them have been called cardiac, hepatic, nephritic subjects, etc. *Old age*, as a permanent general condition characterized by various degenerations of the viscera (steatosis, sclerosis), *pregnancy, the puerperal state*, and *acute anæmia*, being temporary extra-physiological conditions, may enter into this category.

ON THE RECIPROCAL INFLUENCE OF CONSTITUTIONAL CONDITIONS AND INJURIES.

Pre-existing or *propathic* general conditions may exercise an influence upon injuries in various ways:—

Primarily, by favoring the development of certain complications which are situated at the site of injury, or start from it; inflammation, circumscribed or diffuse; lymphangeitis; erysipelas; hemorrhage; neuralgia; alteration of the granular membrane, etc.

Secondarily, by modifying, arresting, and disturbing the reparative process; by destroying what has already been accomplished (ulceration of cicatrices, softening of callus); by replacing an affection of a determinate and calculable duration, the *trauma*, by another affection the length of which we are unable to foresee.

Finally, by fixing themselves upon the point already wounded and become the place of least resistance (*locus minoris resistentiæ*), in order to develop there a more or less obstinate diathetic manifestation.

On the other hand, traumatism may exercise an evident action upon pre-existing constitutional states; it may call them to the wounded spot, awaken or reawaken them, make them pass from a latent to an active condition, and cause their manifestations to appear at the site of injury itself, or in distant regions, if not throughout the entire economy. It usually hastens the course of the diathesis, and more especially aggravates the lesions which that has already produced, and which may have been more or less stationary before the injury.

But this is not true of all cases. The constitutional affection and the injury may at first run parallel to each other, without influencing each other in the least; the subject of the diathesis supports the shock as if he were perfectly healthy, while the wound on the other hand runs a regular and classical course. These fortunate cases are not very rare; we are beginning to be able to foresee them, and we shall undoubtedly soon succeed in increasing their proportion. In the second place, the influence of the trauma upon the constitutional disease is not always unfavorable, but rather the contrary; for the local affection may perhaps be the cause as well as the effect of the general malady, in which event, its suppression exercises the most prompt and decisive action upon the re-establishment of health. It is in this way, for example, that our operations act so effectually against chronic septicæmias. Finally, even when the simple or reciprocal influence of the injury upon the primary disease is exercised in an unfavorable manner, the resulting morbid actions are not always very disastrous.

On the other hand, diatheses only have a limited pathogenic influence; accidental causes, including injury, can only make them produce a certain number of determinate local manifestations, which cannot differ, and in reality do not essentially differ, whether they have been produced by main force, and as it were unseasonably, or whether they have been developed spontaneously in consequence of the natural evolution of the malady.

From a clinical point of view, constitutional diseases present numberless differences: they are active or latent; of recent date or of long standing; of slow or of rapid course; with a constant tendency towards aggravation or

towards recovery; capable of yielding to treatment or of obstinately resisting it; still compatible with a moderate degree of health, or impairing more or less deeply the more important functions; sometimes single, sometimes combined or associated with one another in such a manner as to create hybrid forms, which are very little known despite their extreme frequency and great interest. It is hardly necessary to add that each constitutional disease presents mild and grave, acute and chronic varieties; and that for some of them, syphilis and scrofula for example, stages and periods are properly recognized. All these considerations enable us to understand, *a priori*, that operative and accidental traumata cannot have a uniform action upon dissimilar subjects, and that, on the other hand, different diseases cannot react in the same manner upon the traumatic process.

But observation will show even better that the prognosis of operations varies infinitely in one or another panpathy, because each constitutional disease interferes with the reparative process in its own way, and because the same surgical wound reacts in a peculiar manner upon each particular subject of a diathesis. I do not know how many observations would have to be made, nor how much time devoted to their analysis, before making a generalization and obtaining exact indications for practice; but, in the mean time, I can enunciate certain synthetic remarks which I believe to be already sufficiently firmly established. They are not based on clinical history, but on pathological anatomy.

Without underestimating the large gaps which this important branch of medicine still presents with reference to general diseases (and it is known that this reproach is emphasized by the latest representatives of the purely clinical school), we may nevertheless recognize in these affections three distinct phases: (1) that of *dyscrasia*, usually opening the scene, continuing perhaps permanently, and representing alone the morbid condition; characterized essentially by a change in the fluids, which, unfortunately, we are still far from understanding even with regard to the most frequent diathesis; (2) that of *peripheral lesions*, appeciable to the chemist or pathological anatomist, but slight, or affecting organs of secondary importance; and finally (3) that of *visceral lesions*, with two varieties which must be distinguished according as the organs are affected by a common or general pathological process—phlogosis, sclerosis, cirrhosis, steatosis, amylosis; or are the site of a heteromorphous deposit peculiar to certain general diseases—tubercles, gummata, lithiasis, various neoplasms.

The following is the result of experience derived from a large number of cases taken from my own practice or that of others: in the purely *dyscrasic period*, the patients tolerate operations almost as well as healthy subjects; the manifestations of constitutional disease, when they make their appearance, are usually of little gravity and but temporary; and, if the changes of the fluids are still slight, the reparative process proceeds with sufficient regularity. During the period of *peripheral lesions*, the reaction of the trauma may be more grave, because it finds, in the more or less seriously affected tissues, systems or organs, places of least resistance, thoroughly prepared for fresh diathetic manifestations or an aggravation of the pre-existing disorders. Anomalies in the local process are to be so much the more dreaded, as the concomitant dyscrasia is the more pronounced. During the period of *visceral lesions*, the dangers are greatly increased, because the morbid process is peculiarly complicated. In the first place, the sites (*loci*) of least resistance being situated in organs essential to life, the reaction of the traumatism upon them gives rise to, or aggravates, affections regarded as serious at all times and in every case, and in which there is great danger to life. The dyscrasia too, in its turn, reaches its height, fostered as it is by two causes: (1) the humoral

changes due to the constitutional disease, and (2) that other adulteration of the fluids which inevitably results from imperfect or perverted function of an important viscus; hence conditions which are extremely unfavorable for the progress of the trauma towards recovery. I believe also that I can point out a third source of danger which has, I think, hitherto passed unnoticed. The injured region, it is commonly believed, is capable of developing an organic poison, the entrance of which into the economy produces a true intoxication, viz., traumatic septicæmia. The latter is of variable intensity, according to the quality or quantity of the poison, its accumulation or elimination. Under ordinary conditions and in healthy subjects, the large viscera serve as emunctories for this poison as for so many others. But if this vent be closed on account of a profound lesion of the glandular parenchymata, elimination is rendered impossible, and those acute septicæmias are found to be developed which so rapidly lead to death.

All these propositions would gain in clearness by being sufficiently developed or illustrated by examples, and I greatly fear that they will not be understood in the concise shape under which I present them; but I am limited as to space, and cannot dilate further upon this part of the subject.

The conduct of the surgeon follows naturally from what has gone before. Since the subjects of diatheses cannot be deprived of the benefits of surgical interference, even though this be particularly dangerous to them, the surgeon should strive to lessen the gravity of the prognosis, and to insure at least operative success, that is, the immediate result of his operation. In cases in which he cannot do this, he had better abstain, unless indeed he does not seek the cure of the disease, and is content with merely checking its progress. Fortunately, he will often succeed in averting the accidents which arise from the constitutional condition, by the aid of a series of readily executed measures.

In the first place, he will carefully choose his *time*. If this is impracticable in urgent cases, the rule of *occasio præceps* is, on the contrary, easily followed when, life not being immediately threatened, we can hasten or delay the time of action. As regards the majority of morbid states, we should operate quickly, during the dyscrasic period, before the onset of the histological, and especially of the visceral lesions. In the two chief constitutional diseases, arthritism and scrofula, the latent period is preferable to that in which fresh manifestations occur. We may allow certain diatheses, like syphilis, to wear themselves out; but, on the other hand, we should attack at the onset those neoplasms which are still local, and the extension and generalization of which are imminent.

Great care should be taken with regard to the *operative procedure*. We must be very sparing of blood in exhausted or poisoned subjects; must save neuropathic individuals as much pain as possible; and must prevent, as much as we can, traumatic fever in those whose viscera are affected. An exceptional and little used method may become the plan of election in a particular instance. Diabetic phlegmons and carbuncles should be incised by the thermo-cautery and hot iron, not with the bistoury. Methods of slow and progressive division would, on the contrary, be injurious in irritable subjects, whom pain exhausts and irritates.

The choice of a *dressing* also merits special attention. I may remark, in the first place, that diathetic patients, like all others, owe thanks to the antiseptic method. Whenever possible, the judicious employment of various forms of this method: the wadding dressing of Alphonse Guérin, Lister's dressing, the open antiseptic dressing, etc., counterbalance to a considerable extent the unfavorable influences of constitutional diseases. Under the wadding bandage, I have seen alcoholics and diabetics recover, who would almost undoubtedly have succumbed ten years ago with the old-fashioned dressings. I

have obtained wonderful results with the permanent antiseptic bath and with open dressings. Lister and his disciples daily perform similar miracles which throw into relief the great part played by the traumatic centre in the production of complications. We must not, however, run into extremes; and in considering how very favorable is the suppression of traumatic fever in diathetic individuals, we must not imagine that all danger ceases from merely treating the wounds antiseptically. If this were so, the influence of constitutional conditions would be entirely neutralized to-day, and these pages would be unnecessary.

I know not whether in the future affairs will run such a course that we need not fear the deterioration of the economy by antecedent diseases, but unfortunately we have not arrived at that stage at present. With the antiseptic method we lose indeed fewer, many fewer patients; but we still lose some, and a careful examination of the causes of death clearly shows us that they consist almost exclusively in bad constitutional conditions of the injured persons. We may add, moreover, that antiseptic dressings, in order to be really efficacious, should be applied rigorously, and that such applications cannot always be effected in the actual condition of science. In order to prove this, it is only necessary to refer to the extensive class of *operations in cavities*, that we may remind the surgeon that, under many circumstances, he must still combat the evil influence of general disease.

But the point which must be insisted on most strongly, is the necessity of instituting during, after, and especially before the operation, if there be no urgency, a plan of treatment in which are associated hygiene, diet, the use of drugs—medical treatment *par excellence*—designed to combat the constitutional disease, as would be done were no surgical complication present. Not only, by such a plan, will the chances of the immediate success of the operation be increased, but we will often have the good fortune of indefinitely delaying the injurious relapses of the diathesis. It may even happen that, while merely attempting a preparation which shall be favorable to the final result, there may be obtained, by medical treatment alone, a recovery as brilliant and much less onerous than that which was expected from the knife.

After these general considerations upon the reciprocal influence of constitutional diseases and traumatic lesions, we will now begin the study of the relations of each panpathy to wounds.

Arthritism.

(*Rheumatism*, *Gout*, *Herpetism.*)

Rheumatism.—(1) *Influence of Rheumatism upon the Seat of Injury.*—The rheumatic diathesis has not, like syphilis and scrofula, the property of impressing a peculiar stamp upon the traumatic lesion; it does not even modify to an appreciable extent the reparative process as do alcoholism and diabetes. Neither favoring the production of pus, nor counting among its morbid processes either ulceration, gangrene, or diffuse inflammation, it has hardly any tendency to modify surgical wounds unfavorably, to increase or alter the suppuration, to prevent the formation and transformation of the granular membrane. Open wounds, therefore, have commonly a good appearance in rheumatic patients, and run their course in the usual manner. Certain specific complications may, however, occur at the wounded point, which are observed not unfrequently and are easily recognized. It is known that even a slight articular lesion in a rheumatic patient readily gives rise to a hydrarthrosis, a more or less obstinate synovitis, or even loose bodies; and that a luxation, a

sprain, a penetrating or even epiphyseal fracture, may prematurely give rise to the characteristic lesions of dry arthritis, and sometimes even to true or false anchylosis. The rheumatic diathesis, in the various places in which its spontaneous manifestations arise, very readily and rapidly causes serous effusions, œdema, plastic exudations, temporary or permanent (under the form of various neoplasms—fibroma, cancer, etc.), simple or hemorrhagic congestions, all accompanied by severe pains, fixed or wandering, temporary, intermittent, remittent or continuous, assuming the form of local hyperæsthesia or irradiated neuralgia; and, on carefully watching an injured rheumatic, it is easy to recognize at the seat of injury, or in its immediate neighborhood, an entire series of anatomical lesions of functional disorders, having the greatest resemblance with those which have been mentioned—lesions and disorders which, to my mind, constitute the arthritic complications of wounds. Among these, for example, I include serous effusions in cavities or connective tissue, marked cellular proliferation, pseudo-phlegmons, active hemorrhages, erythema and other severe eruptions in the neighborhood of the wound, neuralgia, and, at a later period, neoplasms and certain affections of the cicatrix.

(2) *Influence of Injuries upon Rheumatism.*—It would be undoubtedly proper to distinguish cases according as the injury occurred before, during, or after the rheumatic attack; but the facts are wanting for the carrying out of this programme. There are scarcely any observations on record of wounds contracted during an attack of articular rheumatism; those of wounds prior to the first rheumatic manifestations, and which produce the unexpected and premature appearance of the diathesis, are equally rare. Nothing is more common, on the contrary, than the renewal of rheumatic symptoms of older or more recent date. This fact, equally well known to the physician and surgeon, has been recognized in a summary manner for a long time. The wounds which may excite the diathesis are extremely varied; strains, fractures, slight or serious contusions, the most varied surgical operations, the removal of tumors, incision of fistulæ, lithotomy and lithotrity, etc. In their turn, the manifestations of the diathesis thus reawakened, are no less variable; sometimes the entire economy is disturbed by a fresh attack of acute, generalized rheumatism, sometimes there is only a local affection, striking a part which had been previously involved, without this predisposing condition being however necessary. We find recorded cases of acute or chronic arthritis, certain cutaneous eruptions (herpes among others), neuralgic pains, muscular spasms, contractions, pericarditis, cystitis, pulmonary congestion, hepatic or nephritic colic, changes in the urine, profuse sweats, etc.

Chronic rheumatism affecting important organs, such as the heart, lungs, kidneys, and walls of vessels, may at length affect their structure more or less profoundly, and convert them into weak points which will feel the effects of the traumatism. But the complications which then arise have only distant relations with rheumatism, and may be more conveniently studied when we come to the special consideration of the constitutional conditions developed by affections of the great viscera.

Gout.—Like rheumatism, gout generally respects the reparative process, and usually does not interfere with the cicatrization of wounds. Nevertheless it is sometimes manifested at the site of injury by fluxions with acute pains, which are capable of simulating frank inflammation, but which are only congestions, usually of a temporary character. The pain also occurs without any apparent lesion, and under the form of neuralgia. In these cases, indeed, the curative process is temporarily suspended or at least retarded. At a later period, chalk stones may appear around wounded joints, and in cases of fracture exuberant callus has been observed. Repeated slight injuries

in the gouty may probably have for their effect the development of certain neoplasms, especially epithelioma. Subcutaneous lesions and sprains are more liable to be followed by manifestations of the diathesis than open wounds.

The traumatism in its turn, has an effect upon the disease. There is hardly any example known of an injury contracted during an attack of gout, or which has excited the first attack of a previously latent gout. In the cases observed, the injury occurred in the interval between two attacks, in a gouty patient who had previously suffered more or less often. As a rule, the attacks thus provoked by main force develop quickly (from the first to the fourth day for example), are of but moderate intensity and brief duration, and appear to be excited preferably by slight injuries. I have, for instance, twice seen gout follow puncture of a hydrocele with a very fine trocar. In one case in which an injection of iodine had been made, the attack appeared to act as a derivative, for the inflammation of the tunica vaginalis was to a great extent wanting, causing extreme slowness of recovery. In cases of chronic gout or gouty cachexia in gouty subjects affected with renal or hepatic lesions, the prognosis is rendered grave. More or less serious complications may invade the seat of traumatism, but must be especially attributed to the visceral changes, rather than to the gouty dyscrasia.

Herpetism.—I give this condition a place here, although I do not consider it either a distinct diathesis, or a separate constitutional disease. To my mind herpetics are simply arthritic subjects in whom the predominant manifestations are on the part of the mucous membrane and the skin. Herpetism then acts upon injuries only after the manner of rheumatism, and especially of gout, by producing at the site of the injury early or late neuralgias, either intermittent, remittent, or continuous; and, in the integument near the seat of traumatism, congestions, fluxions, and, finally, various cutaneous affections, among which herpes occupies the first rank, as shown by the numerous observations of traumatic herpes which have already been recorded. Traumatism is undoubtedly a determining cause of herpetic manifestations; it produces cutaneous eruptions at places in which they have never appeared before, brings back with the greatest facility those which have disappeared, and prolongs the existence of those which are already present in the wounded region. Wounds, properly speaking, act much more effectually in this respect than deep-seated injuries, whether or not involving the great cavities.

Cancer.

Surgical operations are so frequent in cancerous individuals, that it is natural to inquire whether or not cancer influences injuries, and in the event of an affirmative answer, what changes it produces in the reparative process. Now it must be remembered in the first place that cancer, in spite of what has been said on the subject, is not a distinct constitutional disease; that it is included in a much more extensive diathesis, the neoplastic diathesis, or the tendency to produce neoplasms spontaneously, or under the action of a determining cause; that the neoplastic diathesis itself is strictly dependent upon arthritism—which is equivalent to saying that neoplastic and cancerous subjects are merely arthritic patients suffering from a special manifestation of the constitutional disease. We might therefore simply refer to the preceding paragraphs; but a few special remarks will perhaps not be useless.

Cancerous subjects belong to various categories. In some, the disease is latent, in a condition of predisposition; in others, it already exists in well-defined manifestations. Some present only a single tumor, others have seve-

ral cancerous deposits scattered over various parts of the body; sometimes the morbid masses are situated in the external parts, the limbs or walls of the splanchnic cavities, sometimes they occupy the viscera or deep parenchymata; often they are observed both externally and internally. Finally, certain cancerous patients present no other lesions than the single or multiple tumors with which they are affected, while in others we find humoral changes, or more or less serious disorders in organs which are free from all neoplastic deposits. In certain predisposed subjects, injuries, and almost exclusively contusions, appear to invite the manifestations of the disease. Before complete recovery, or a longer or shorter time after apparent recovery, the centre of traumatism is invaded by the neoplasm, and the cancer appears at the seat of injury.

Cancerous patients who are affected by single tumors situated in organs not essential to life, and whose viscera are healthy, tolerate injuries well; the reparative process pursues a normal course. The only complications to be feared are those which are observed in arthritics, and which usually present but slight gravity; such are traumatic herpes, early secondary neuralgias, recurrent attacks of rheumatism or gouty paroxysms, etc. I know of no authentic example of an open wound in a cancerous subject, in a region exempt from cancer, which has itself undergone the cancerous metamorphosis. In cases of removal of tumors, when the ablation has been early and free, the cicatrices are healthy, firm, and usually not liable to relapses, which readily occur, on the other hand, in distant localities.

Cancerous patients affected by multiple deposits, and especially by visceral tumors, tolerate accidental wounds and surgical operations very badly. A large proportion succumb in consequence of even slight injuries, such as simple fractures, the removal of small tumors, palliative operations, tracheotomy, formation of artificial anus, etc. The seat of injury may become the site of the ordinary complications of wounds: inflammation, hemorrhage, erysipelas, pyæmia, etc., but more frequently still we notice merely an almost entire absence of the reparative process; immediate union, cleansing of the wound, formation of the granular membrane—all are wanting. At the same time, there are high fever and profound adynamia; and death often occurs very rapidly without its being possible to ascribe it to any of the recognized complications of wounds. The same termination is usual in cachectic cancerous patients, in whom the large viscera (liver, kidneys, heart) are affected by fatty degeneration. The complications which cause the fatal result are always better characterized in them, and we find the classical causes of operative failure, diffuse inflammation, severe erysipelas, septicæmia, pyæmia, secondary hemorrhage, etc.

Such a case as the following, which is unfortunately very common, cannot be explained with our present knowledge. An operation is performed upon a readily accessible, external tumor, in a cancerous subject who is apparently free from all internal lesions, and who presents the appearances of satisfactory health. The wound does not advance towards recovery, general symptoms appear, death occurs with or without local complications, and nothing is found at the autopsy except a few, small, cancerous nodules scattered through the lungs, liver, or other viscera, and the existence of which had not been suspected. Though the traumatism may produce the premature appearance of cancer by making the injured part the port of entry and place of election, it reacts even more frequently upon pre-existing cancerous tumors. It usually accelerates their course, and causes an active increase of the proliferation. This is especially observed in cases of wounds of the tumor itself, such as contusions, exploratory punctures, incomplete operations, etc. But this irritating action is exercised equally at a distance. Many times we find that small,

indolent, stationary glands, which it was not thought necessary to remove when operating upon the principal tumor, rapidly attain a considerable size, soften, and ulcerate. Before performing castration, the iliac and perineal regions may have been examined with the greatest care, and nothing suspicious have been discovered; but the cicatrization of the scrotal wound is scarcely effected before the patient complains of lumbar and abdominal pains, and palpation discloses, deep in the abdomen, tumors which grow with extreme rapidity.

Injuries not due to operations have the same stimulating power; those which are least severe, such as simple fractures or contusions of the limbs (very remote, therefore, from visceral cancers), may aggravate the latter to such a degree as to produce an entirely unexpected death within a few days. In some exceptional cases, the injury, especially if it is of an operative nature, appears to cause a temporary revulsion and to arrest the general progress of the disease. This respite is usually temporary; the wound has scarcely cicatrized before the cancerous deposits assume or resume their destructive course. Surgical operations for cancer, when accompanied by profuse loss of blood, or followed by profuse or prolonged suppuration, manifestly hasten the progress of the cachexia.

Scrofula.

Bearing in mind the morbid processes habitually met with in the scrofulous: inflammation, not severe but obstinate, of slow course, and often chronic from the beginning; abundant connective-tissue proliferation, readily set up by local irritation, but remaining stationary and able neither to disappear nor to complete its organization; suppuration without inflammatory reaction of the surrounding parts, often profuse and kept with difficulty within bounds; indolent, atonic, interminable ulcers, which return on the slightest occasions, etc.—we can readily understand what modifications this constitutional disease can produce on the various acts of the reparative process.

At first, this process appears to progress as well as could be wished; the traumatic irritation and local inflammation are moderate, circumscribed, without tendency to diffusion, accompanied by scarcely any pain; immediate union is often attained, and, in cases of open wounds, the granular membrane is rapidly formed. After this first effort, however, everything seems to have come to a stop; the suppuration becomes thin and serous; the granulations grow pale, swell up, and soften; the edges of the ulcer, which have approached one another, separate, gape open, and grow thin; the wound is replaced by an ulceration which, after a short period, differs but little from a scrofulous ulcer that has developed spontaneously. In case of interstitial injury, the connective-tissue proliferation appears under the form of diffuse swelling, fungous growths of the synovial membranes, and thickening of the periosteum; suppuration commonly occurs in this centre of induration, in which, without doubt, tubercles are sometimes developed. These abscesses are followed by inevitable and interminable fistulæ, with blind pouches, suppurating tracts, and separations of tissue, whence stagnation and alteration of pus, almost inevitably giving rise to chronic septicæmia and its consequences, especially if various parts of the skeleton are involved. Recovery, however, sometimes occurs after a longer or shorter period, but it is not rare to find a relapse of the local complications, either on account of fresh violence, even slight, affecting the parts formerly injured; or under the influence of an intercurrent disease; or from the progress of the scrofula as regards the viscera; or, finally, from the onset of tuberculosis. There is nothing

more common in such cases than the relapse of osteitis or arthritis, the return of abscesses, reopening of fistulæ, etc.

Scrofula has so great an influence on the reparative process that it impresses its seal even upon the cutaneous cicatrices, which remain indelible and perfectly characteristic throughout life. On the other hand, scrofula possesses to such a high degree the vexatious power of indefinitely prolonging traumatic lesions, that it must always be looked for, even in individuals of very healthy appearance, whenever recovery from a wound is much delayed.

Wounds inflicted by the surgeon act in precisely the same manner as accidental injuries. Their early phases are almost exempt from dangers, and very rarely attended by wound-complications, such as phlegmon, gangrene, hemorrhage, pyæmia, etc. The lymphangeitis and erysipelas which sometimes start from them are transient, and without violent reaction. Accordingly, every one declares the mildness of operations in the scrofulous. This opinion should, however, be combated, or at least modified. It is true that rapid death is exceptional, but complete and permanent recovery is not much more common. If we trace the results of operations on scrofulous subjects with sufficient perseverance, we will notice the extreme frequency of half-successes, of incomplete results, of unfinished cures, of relapses at an earlier or later period; so that it is exceptional to find a scrofulous patient upon whom resection or amputation has been performed, who is sound and healthy ten years after the operation.

Traumatism possesses to a high degree the power of awakening, reawakening, and aggravating scrofula, whether latent or already declared. In slight cases, it causes from time to time the first manifestation, in children of fine appearance, of the superficial and slight symptoms of the diathesis: rashes; cutaneous eruptions, impetiginous or otherwise; subacute or indolent adenopathies. More frequently still it stimulates extinct or languishing centres of disease, and restores to local affections their original severity. Cures which were believed to be radical, or, at least, near at hand, are thus again rendered doubtful. Finally, when there are visceral lesions derived directly from scrofula, such as tubercle of the lungs, intestines, mesentery, or nervous centres; or which are but consequent upon prolonged suppuration and chronic septicæmia, such as fatty and waxy degenerations of the liver, kidneys, spleen, and intestines; the injury almost always proves fatal by the more or less sudden aggravation of affections which no doubt rendered life precarious, but which nevertheless, except for the traumatic shock, would have permitted the patient to live for some months, or perhaps even for some years, longer.

At this stage of scrofula, the subjects of wounds or operations may undoubtedly succumb to local complications, but much more frequently die of marasmus and exhaustion—that is to say, of phthisis, albuminuria, anasarca, uncontrollable diarrhœa and inanition—or of cerebral complications.

Tuberculosis.

If pulmonary tuberculosis may, without hereditary antecedents or evident predisposition, appear in the last stages of almost all constitutional diseases, such as arthritism, syphilis, diabetes, alcoholism, etc., and even of affections which have only involved the digestive functions, such as simple stricture or carcinoma of the œsophagus or rectum, epithelioma of the tongue, etc., it is none the less true that, in the immense majority of cases, tuberculosis is an appendant of scrofula, or that, in other words, tuberculous subjects are merely scrofulous subjects of a certain variety.

The statements made in the preceding paragraph might therefore be applied

to the reciprocal relations of tuberculosis and traumatism. It must be remarked, however, that as the mere presence of tubercles in any organ whatever indicates at once a serious condition of the economy—a dangerous form of scrofula—we must expect to find the reparative process hindered, and recovery retarded or indefinitely delayed, in wounded persons who are tuberculous. This fact has been amply demonstrated. The observations are numerous in which amputations, in tuberculous patients, have been followed by acute atrophy of the flaps, by inflammation, by conicity of the stump, etc. This influence of tuberculosis upon the course and termination of operations has been known for a long time; for we find the question discussed in old books whether it is wise or not to amputate in phthisical cases, or even to operate upon simple anal fistulæ. The advocates of abstention find no difficulty in making evident, in the large majority of cases, not only the dangers but also the uselessness of surgical procedures which merely substitute for one chronic lesion another almost identical in character. Other authors, indeed, furnish facts which are favorable to intervention. The affirmative and negative conclusions of our predecessors are much too general, and do not reflect sufficiently the extreme diversity of cases presented in practice. In fact, the unfavorable chances are singularly increased or diminished according as the tubercles are deep or superficial; abundant, generalized and large, or rare, discrete and small; as they are in course of genesis or rapid evolution, or stationary and in course of fatty or calcareous degeneration; or, finally, as they have more or less disorganized the organ which they occupy.

Writers, again, have had too exclusively in view pulmonary tuberculosis, and have left out of sight tuberculization of the brain, mesentery, genital organs, bones, glands, etc. Even in respect to pulmonary phthisis itself, in considering the indications and contra-indications for operation, the surgeon should have regard to its extent, its degree, its forms, its origin, and its causes.

Finally, we must not accept or reject indiscriminately all operations, but consider each one separately. Thus, if resections must be avoided in tuberculous individuals, we may sometimes, if only for the purpose of prolonging life and rendering it more comfortable, perform amputation, and, generally speaking, may employ the whole series of urgent, and a certain number of palliative operations.

Scurvy.

Essentially characterized by a change in the blood, by friability of the vascular walls, and by fatty degeneration of the tissues and especially of the liver, scurvy offers all the conditions necessary for the production of various complications at the seat of injury. The most important is naturally *hemorrhage*, so easily provoked by the least violence exercised upon the vessels and tissues, that it is almost always of traumatic origin, even when appearing to be spontaneous. The discharge of blood occurs at all parts: externally, into the cavities, into the interstices of the tissues; and gives rise not only to hemorrhage properly so called, but to all the possible varieties of blood-extravasation—extensive ecchymoses, suffusions, infiltrations, effusions, blood-tumors, etc. To this first cause of delay in the local reparative process, must be added the more or less complete *absence of the neoplastic function;* definitive histological regenerations are especially defective. Hence atonic, obstinate ulcerations of bad appearance; interminable suppuration; delay in the consolidation of fractures; or production of permanent pseudarthrosis. The callus already formed may soften a longer or shorter time after the fracture; cases are even cited in which callus, that had been solid for several years, softened in consequence of an attack of scurvy.

Nothing justifies the belief that injury may produce scurvy. Cases have been reported in which a wound, occurring in a subject of healthy appearance, assumed a scorbutic aspect, after which the other symptoms of the disease soon showed themselves; but this can be explained as well by saying that, at the period of injury, the scurvy did not exist, and that it was developed as an intercurrent disease; or that it was yet latent and ill-defined, and that, after the manner of other diatheses, it first showed itself at the seat of injury as at the place of least resistance. In confirmed scorbutics, wounds sensibly aggravate the general condition, and contribute to the decay of the organism, by primary or secondary loss of blood, and by prolonged suppuration.

Leucocythæmia.

The number of cases hitherto collected is still very small, but is already sufficient to prove the disastrous influence exercised by leucocythæmia upon accidental or operative wounds. The most frequently observed complication, at the site of injury, is rapid or slow *hemorrhage*, which is almost always uncontrollable, and almost inevitably leads to death. This hemorrhage does not appear after capital operations only, but follows also insignificant wounds, such as biting the tongue, paracentesis abdominis, the application of leeches, lancing the gums, etc. The few patients operated upon who do not perish from loss of blood, die of phlegmon, phlebitis, pyæmia, or peritonitis, especially after splenotomy—an operation, which has now been practised at least fifteen times upon leucocythæmic patients, and which has, under these circumstances, always been followed by death.

Certain more or less conclusive observations lead to the belief that injuries may by themselves engender leucocythæmia. Splenic contusions have been cited in the first place—cases in which the hypothesis is acceptable; then a fracture of the thigh, a sprain, the extirpation of tonsils in a state of chronic inflammation; in a word, injuries not primarily affecting the spleen. With regard to the latter cases, at least, it appears more probable that the leucocythæmia pre-existed, but in a mild and latent condition, and that the injury aggravated and rendered it evident. This stimulating action is moreover demonstrated by a case in which a wound of the leg gave rise to peritonitis starting from the diseased spleen. Injuries sometimes shake the organism of leucocythæmic patients to such a degree that they immediately sink into a rapidly fatal collapse.

Hæmophilia.

It would certainly be surprising not to find in the list of constitutional conditions bearing a relation to traumatism, this condition, peculiar to certain individuals, in whom the blood tends to escape by every channel, and in whom there is no tendency to the production of spontaneous hæmostasis.

However, before recalling what is contained in the books, I experience a certain embarrassment, because, in my tolerably large experience, I have never seen a case of hæmophilia; because the subjects in whom I have myself observed this tendency to bleed, and this difficulty of hæmostasis, have been merely patients suffering from hepatic disease, malaria, diabetes, scurvy, leucocythæmia, etc.; because among the published observations the majority are very incomplete from a clinical point of view as well as in reference to pathological anatomy; because, moreover, these observations become more and more rare in proportion as we become better acquainted with diathetic hemorrhages; because, to express my meaning in one word, I am in no

degree convinced that there is such a special condition, deserving a special place in nosology and a special name, and because, if hæmophilia really has an existence, I shall wait for it to be a little better demonstrated.

Syphilis.

During its always prolonged, if not indefinite, duration, syphilis may show itself or disappear several times, or be, in other words, alternately manifest or latent. The first condition is common in the beginning of the disease, during the first two or three years or even later, when treatment has been wanting or imperfect. In the opposite condition, the syphilitic may enjoy excellent health for a long term of years without any apparent symptoms. Syphilis may, therefore, be recent or old, evident or masked, when the injury occurs. In the immense majority of cases, the wound progresses naturally without appearing to be influenced by the constitutional disease, but the reverse sometimes occurs, so that the work of repair is more or less interfered with. It will not be useless, in order that the modifications undergone may be appreciated, to recall the circumstance that the pathological processes of syphilis strongly resemble those of scrofula. In fact, we find here the same proliferation and connective-tissue new formation—abundant, but useless, superfluous, even hurtful, as the new tissue strangles the old and finally replaces it by fibrous or cicatricial products. We also observe the tendency to obstinate ulceration and indefinitely delayed repair. It is to be remarked that the two constitutional diseases attack the same systems: the external or internal tegument, osseous system, lymphatic system, etc.; and that, finally, in their last stages or their grave forms, they generate products which are to a certain extent special and closely related, the tubercle on the one hand and the gumma on the other. We should, however, remember to the credit of syphilis, the much more pronounced tendency of its local manifestations to disappear spontaneously, or to yield to treatment, though ready to return on the slightest occasion, under the same form, or even under a different aspect.

These facts enable us to understand what sometimes occurs at the seat of injury: in cases of fracture—delay or complete absence of consolidation, the repair being restricted to the formation of fibrous callus which does not undergo ossification; in cases of simple contusion of bone—osteitis, periostitis, exostosis, periostosis, suppurating gummata, subperiosteal abscesses, osseous denudations, necroses which are interminable on account of the non-formation of natural sequestra. A contusion, even if confined to the soft parts, sometimes gives rise to indolent phlegmons which pursue a chronic course, with scarcely any suppuration, and which leave behind them either fistulæ, or indurations, or ulcerating wounds. If the contusion be severe and circumscribed, the skin may become gangrenous, and, upon the separation of the eschar, we find a wound which possesses all the characteristics of an ulcerating syphilide or gumma.

Wounds made by cutting instruments may also suffer the influence of the diathesis, although this is of rarer occurrence. A failure of immediate union has in the first place been noticed, and, as a consequence, an unsuccessful result of autoplasties; then again there may be early or late modifications in the course of the cicatrization. Sometimes the wound assumes the appearance of an ulcerating or perhaps even of a serpiginous syphilide; sometimes it ulcerates without assuming a specific appearance, and does not heal; finally, it may retain the appearances of an ordinary wound, but persist indefinitely, or it may cicatrize after a certain time only to break open again in a short

period. As for the rest, there is complete uncertainty as to the period at which the diathesis will disturb the curative process. This disturbance, in fact, may occur immediately after the injury, a few days afterwards, or even some weeks or months subsequently. It is common to find that the wound at first follows a normal course, then remains stationary, and finally assumes a syphilitic aspect.

Syphilis seldom attacks wounds during the first months of its existence; it affects them more readily when it is of older date; when it has, as it were, impregnated the economy more intimately. However, we can formulate no distinct rule in this respect, since, in a very large number of cases, wounds have been found to undergo the specific metamorphosis in patients who have been free from all syphilitic manifestations for ten, fifteen, or twenty years, or even longer. The chances of the occurrence of this metamorphosis appear moreover to be the greatest when the injury affects tissues already changed, even though from other than syphilitic causes. Furthermore, other examples equally prove the predilection with which syphilis takes hold of places of least resistance which have become such a longer or shorter period before its invasion. Thus it has more than once been found to select as the site of its local manifestations some old seat of traumatism which had become entirely extinct, and the cure of which would otherwise have remained permanent.

If the quality of the wounded tissues establishes an evident predisposition; if the quality of the poison is also probably a factor in the determination of the mild, moderate, or grave forms of the disease; surely we are permitted to believe *a priori* that the character of the constitution, that is to say the anterior constitutional condition of the wounded syphilitic, will react upon the injury, aid in modifying its course and termination, and recall, in certain cases, the diathetic manifestation. But we must remember that, however probable this may be, it has not been demonstrated. In syphilitics who are in a condition of cachexia, or who suffer from grave visceral lesions of the liver, lungs, kidneys, or nerve-centres, the reparative process goes on no better than in other subjects whose health is ruined, and may be complicated by disorders common to all cachexiæ, such as gangrene, hemorrhage, diffuse inflammations, etc. In these disorders, the part played by syphilis, properly speaking, is relatively small, or at least very indirect.

Let us now speak of the reciprocal action. It is absent much more frequently than it is present; we will here consider only those cases in which it is manifest.

Of course, an injury cannot produce syphilis; but it may introduce it into the economy, attract it to the wounded point, aggravate it, and make it pass from the latent to the active stage. In the immense majority of cases, the infection is produced through the medium of an injury, though very slight and almost microscopical. We have already said that old wounds are sometimes attacked by syphilitic complications in preference to healthy tissues, but the most common cases are those in which the injury affects syphilitics who have been infected for a longer or shorter period. At this point two facts appear: either evident syphilitic manifestations are present, or the disease is entirely latent. In the first event, the lesions receive a more or less active impetus, and become more or less grave; in the second, they appear to originate full-blown, and to attack organs or regions which had previously escaped. They occur under the form of secondary or tertiary complications, according to the stage to which the intoxication has advanced in the wounded subject. The tertiary stage predominates when the syphilis dates back some years, even when it has never produced any secondary symptoms. These complications appear at the point of injury in the centre of traumatism, or in its neighborhood: they are local manifestations excited by the

trauma; or at a distance, but in a single organ or in a circumscribed region; or finally in several parts of the economy at once, as if there was a recent infection which had become generalized.

The diathetic manifestations thus forcibly provoked by the stimulating action of an injury, are a valuable means of diagnosis, revealing the existence of a syphilitic taint of which the patients themselves are ignorant, or which they believe to have been long since extinct. They usually present no exceptional gravity, and yield quite readily to well directed treatment.

Malaria.

Of all constitutional conditions, malaria is perhaps that which reacts most upon the centre of traumatism, and which reciprocally experiences most frequently the counter-stroke of the injury. Accordingly, in countries in which malarial poisoning is endemic, it is expected that the reparative process should be constantly disturbed by various complications, while wounds, on the other hand, excite or renew attacks of intermittent fever. In our temperate climate, and in large cities, these facts, though of rarer occurrence, are nevertheless met with. Malaria may give rise, at the site of injury, to various complications, such as hemorrhage, neuralgia, erysipelas, spasms, and even tetanus; complications which assume an intermittent type, and which yield to the employment of sulphate of quinia. But the influence of the poison is not always shown by periodical disturbances. We find in fact that certain wounds assume a bad appearance, or at least remain stationary, until, the cause being suspected, preparations of quinine, which act like a charm, are administered. It is especially in cases of malarial cachexia that are observed that slowness and insufficiency of repair which terminate in serious diffuse inflammations, or even in gangrene, and which are not always subdued by antiperiodic remedies.

The injury may occur under the following various circumstances: (1) In a patient actually affected by intermittent fever. In this case the wound, especially if it is followed by hemorrhage, rapidly and markedly aggravates the disease. (2) In a patient who has previously been subject to intermittent fever, but who appears to have entirely recovered. The injury, even when of slight importance, such as a contusion, subcutaneous fracture, puncture, slight wound or operation, and although the recovery from the fever may have occurred many years previously (five, ten, or fifteen years, and even more), reawakens the latter or itself experiences its influence, which shows itself under the form of local intermittent complications. It may even happen that these complications (hemorrhage, neuralgia, spasm), instead of choosing a site at the wounded point, appear in a totally different region of the body, not affected by the traumatism, and thus clearly indicate the return of the disease. (3) In a patient who has never had intermittent fever, and who lives in a healthy country, but who formerly resided in a malarial district. The wound, in such cases, may apparently give rise to intermittent fever or to intermittent complications. It is very clear that the injury, not being able of itself to produce a true intoxication, has merely provoked the explosion of a hitherto latent disease, and forced it to reveal itself by pathognomonic manifestations. These latter cases are not very rare, and are especially observed in large cities and in the healthiest regions. They must not be confounded with other cases in which intermittence is also evident, but which bear no relation to malaria. It appears astonishing at first sight that a disease, which is generally so well characterized and so readily recognized, can remain so long and so completely latent. We will be less surprised if we

recall the fact that the fever is not the sole indication of the malarial poisoning, and that, without having had a single attack in an infected district, the system may nevertheless be impregnated by the disease. Malarial anaemia and concealed neuralgias characterize malaria almost as well as tertian or quartan fever.

Moreover, care must be taken, in whatever district it may be, not to confuse the fever which has been aroused with those quite numerous cases in which periodicity is present without the slightest relation to malarial infection. I will mention, among others, those curious cases of wounds of the spleen which give rise to traumatic splenitis, accompanied by distinctly periodical febrile seizures, and readily amenable to treatment by quinine; as also those equally periodical seizures, which are equally curable by sulphate of quinia, and which are due to affections of the urinary passages, in men suffering from disease of the kidneys.

Alcoholism.

Acute and chronic intoxication must be studied separately. Simple drunkenness modifies certain primary phenomena of wounds, viz., pain and muscular contraction; it may obscure the diagnosis, especially in traumatic lesions of the head and spine; it sometimes renders difficult the treatment of certain surgical affections, by interfering with the application of instruments and dressings; at other times, on the contrary, by causing muscular relaxation, it facilitates the reduction of luxations. Casual drunkenness has generally no marked action upon the course of a wound, and does not prevent the performance of certain urgent operations, such as tracheotomy, catheterization, the arrest of hemorrhage, etc. It constitutes, however, a contra-indication to the employment of anæsthetics. Resort was had to it, in former times, as a therapeutic agent in various surgical affections, such as luxations, tetanus, septicæmia, etc.; but the employment of other anæsthetics is far preferable if we wish to obtain muscular relaxation; and if we desire to use alcohol as an antiseptic, it is useless to push it so far as to cause intoxication. Traumatism sometimes modifies the phenomena of drunkenness, the effects of which it increases or diminishes; now sobering one individual, and again rendering another even more violent.

Chronic alcoholism is a predisposing cause of injury. The drunkard has hallucinations and a tendency to suicide; he readily loses the sense of self-preservation, and commits, even when fasting, a host of extravagances. The keenness of his senses is diminished, as well as the promptness and precision of his protective and defensive acts. If hard drinking and drunkenness should disappear, we could dispense with one-third of the beds in our surgical wards. Chronic alcoholism profoundly modifies the reparative process, is singularly prejudicial to the healing of accidental or operative wounds, and greatly aggravates the prognosis of traumatism in general. In fact, every wound, although of itself of slight importance (contusions, subcutaneous fractures, punctures, excoriations), may be followed by death in drunkards. This termination is often due to complications starting from the wound, such as lymphangeitis, erysipelas, hemorrhage, diffuse phlegmon, gangrenous inflammation, or sphacelus, the whole accompanied or followed by grave traumatic fever or pyæmia, and the entire train of the adynamic and ataxic symptoms of severe blood-poisoning. These complications are the more alarming as the chemical composition and structure of the humors and tissues have been more profoundly modified by the alcohol, and as these disorders affect organs more essential to life, such as the brain, or those more directly concerned with

nutrition, such as the lungs, liver, and kidneys. They do not always cause swift death, and may even disappear quite rapidly; then the curative process, which has been temporarily suspended, resumes its course with more or less activity and rapidity; but it may also be subject to fresh periods of arrest, languish for an indefinite period, and even retrograde. We then observe profuse suppuration, the absence of secondary union, and the formation of atonic wounds and callous ulcers. After various alternations, recovery may finally occur, but it is at least as common to find fresh complications supervene, rendering the local lesions manifestly incurable, and leaving no other alternative than death from cachexia, or surgical interference of the most dangerous kind.

The danger of wounds in drunkards is none the less serious when it comes reciprocally from the action of the traumatism on alcoholism. It is not rare to find that a wound recalls, with more or less violence, the manifestations of alcoholism which is latent, or which has been long believed to have disappeared. In the first rank stands *Delirium Tremens.* This serious complication may arise suddenly, a few hours after the injury, and by a true reflex action upon the previously affected cerebral organ; or it may appear at later periods, when the septic poison originating in the wound and produced by the local complications has more or less poisoned the blood. Be that as it may, this delirium tremens of traumatic origin is of considerable gravity, and often resists all the measures which are directed against it. Delirium is not the only neuropathy which injury may produce or awaken in the victims of alcohol; there must also be noted, epileptiform convulsions, tetanic spasms, hyperæsthesia and anæsthesia, hallucinations, and other psychical disturbances.

The reaction of the traumatism upon the other viscera affected prior to the wound, though less sudden and violent, is none the less very threatening. On the part of the digestive tract appear vomiting, anorexia—sometimes complete—and the malnutrition which results therefrom. When the liver is cirrhotic or fatty, secondary hemorrhages are greatly to be dreaded, as are also albuminuria and uræmic phenomena when the kidneys are affected. In case of fatty degeneration of the heart, we must have in our minds the liability to residual overdistension (*asystolie*), which has been already several times observed in drunkards, and which explains the sudden or very rapid death sometimes observed in their cases. In other words, when we remember that alcohol produces three principal lesions, to wit, fatty degeneration and cirrhosis in the parenchymatous organs, and atheroma in the vessels; and that in inveterate drinkers all the tissues and organs are more or less deteriorated, and all the functions more or less compromised, we may understand that death may occur in several ways, and, in some manner, through all the more important organs.

To certain lesions, however, correspond certain disorders which destroy life by a constant mechanism.

In crushes of the limbs and compound fractures for instance, death occurs from acute septicæmia. The centre of traumatism rapidly becomes the site of an intense phlegmonous inflammation, which extends step by step, and soon involves the entire limb; the connective tissue is infiltrated with gas and putrid fluids; sphacelus at once attacks the contused parts, and cadaveric decomposition appears to commence before death. Surgical interference is almost useless; amputation and resection are unavailing. Antiseptic dressings applied immediately after the accident have saved some wounded alcoholics, but still permit the death of the larger number.

Morphinism.

In regard to morphinism, we possess but few records, and those unaccompanied with many details. Opium administered continuously, and in moderate doses, is rather favorable to the cure of wounds, and more than one surgeon has extolled its use in severe injuries. But, as in the case of alcohol, there is a great difference between use and abuse, and in the same way that there is an acute and a chronic alcoholism, there are also acute and chronic forms of poisoning by opium. The latter variety, which was formerly known only in the Orient, has in its turn invaded the Western world since the extensive employment of narcotics by subcutaneous injection. Chronic morphinism is the only variety with the effects of which upon the course of injuries we are somewhat acquainted. Thus at the locality of hypodermic injections have been noticed phlegmons, abscesses, and spots of gangrene; at the site of operative wounds, erysipelas, bronzed inflammation, orange-colored suppuration; in a word, complications which are very analogous to those observed in alcoholics, and in diabetic and albuminuric patients.

While waiting for carefully made autopsies to show the nature of the histological lesions produced by slow morphia poisoning, experimentation and clinical study enable us to compare morphinism to the constitutional conditions described above. In fact, by injecting toxic doses of morphia in animals, we produce albuminuria, glycosuria, and ocular lesions which are comparable to those caused by these two diseases; and furthermore, examination after death reveals intense congestion of the nerve centres, and of the liver and kidneys. Moreover, this albuminuria and this glycosuria have been already noticed in morphiomaniacs. Charcot, for his part, has observed the development of furious delirium in morphiomaniacs, and in a case of pneumonia this latter affection terminated in gangrene. It is easy to understand that opium-eaters should present at the seat of injury complications with which they might be affected at any point whatever, without its direct implication, and simply in consequence of the poisoning itself or of the visceral lesions which it produces.

We know nothing of the reciprocal influence which traumatism may exercise upon morphinism. We will merely mention as a fact which is interesting to surgeons, that the use of chloroform demands special precautions in individuals who habitually make excessive use of morphia. Though relaxation is usually produced in them with readiness, the narcosis may be prolonged for an extremely long time, and may be accompanied by a depression of temperature which, in some cases, has awakened well-founded apprehensions.

As a sequel to these remarks on morphinism, we should no doubt speak of the more or less analogous intoxications caused by belladonna, tobacco, haschish, and some other narcotic substances. But, unfortunately, we must for the present, in absence of the necessary information, leave blank a space which the future will certainly fill.

Saturnism or Lead-Poisoning.

Animal and vegetable matters do not alone possess the baleful privilege of poisoning the organism, and of giving rise, like general diseases, to permanent constitutional conditions; the metalloids and metals also have the same property. We are in the possession of valuable knowledge with regard to this class of poisonings, several of which have even received special names.

Thus we speak of *iodism*, *mercurialism*, and *saturnism*, and we shall soon speak of *phosphorism*, *arsenicism*, etc. The list will become very markedly extended as soon as shall be included in the pathology of artisans all the special morbid conditions produced by the constant employment of this or that toxic substance.

These poisons naturally bring into the chemical composition of our fluids, and into the histological constitution of our tissues and organs, modifications, some of which have already been well described. Naturally, also, these dyscrasiæ and these peripheral or visceral lesions, modify the reparative process in cases of wounds. Unfortunately, we can here only form conjectures and hypotheses, surgeons not having hitherto concerned themselves with the manner in which injuries act in individuals poisoned by phosphorus, arsenic, mercury, etc.

More anxious to mark a place for these investigations, than capable of illustrating the subject by my personal experience, I have made a short section on saturnism, as I have already collected some observations on wounds occurring in individuals suffering from lead-poisoning. In one, a contusion gave rise to a renewed attack of lead-colic; in another, an insignificant wound of the great toe was followed by lymphangeitis of rapid course; in a third, the onset of saturnism caused the reopening of a focus of suppuration which had been closed for ten years. Two amputations, one of the leg, the other of the arm, performed in patients of this class were not followed by any complications. No conclusions can be reached until we are in possession of a larger number of facts.

Hepatism; Nephrism; Cardism.

We have already laid down the principle that every old or serious lesion of an important viscus, whatever may be its origin and causes, produces, after a longer or shorter interval, a change, first in the chemical composition of the fluids, and then in the anatomical constitution of the solids; creating, in a word, a general morbid condition, imperfectly defined perhaps, but as dangerous to life as a well-determined disease. Such changes inevitably occur in patients suffering from affections of the liver, kidneys, heart, spleen, lungs, intestines, and doubtless also the brain. It is true that, in many of these individuals, the lesions of the liver, kidney, heart, etc., are neither primary nor isolated, and that they form part, on the contrary, of a pre-existing morbid entity—so that, for example, a patient suffering from hepatic disease is an alcoholic, one suffering from kidney disease is gouty, and one from heart disease rheumatic. Nevertheless, while taking the general disease into consideration, great interest attaches to an examination of the peculiar influence exerted upon it by the marked alteration of this or that viscus. In fact, constitutional diseases do not always implicate the same organs, and do not always affect them with the same intensity; not all rheumatics suffer from cardiac disease; not all alcoholics have a diseased liver; and a patient may be gouty though the kidneys are in good condition. Clinically there is room for investigating (1) what differences would be presented by three rheumatic patients, one of whom had a mitral lesion, a second biliary lithiasis, and the third albuminuria; and (2) the differences noticeable in three cases of hepatic disease, in which the causes of the lesions were alcoholism, syphilis, or prolonged suppuration of bone.

In the field of surgery these researches are no less important, experience having shown that injured persons are exposed to serious complications whenever one of the important viscera has been previously affected, and that

there are intimate relations between the nature of the complications and the lesion of this or that organ. I have thought it well to reproduce here some of the information which we possess on this subject. It is necessary, however, to remark that though the framework may be prepared, it cannot at this time be filled up. We possess somewhat precise information only in regard to those conditions which are produced by hepatic, by renal, and by cardiac affections; in the future, the series will undoubtedly be made complete.

Hepatism.—It is difficult to define this condition precisely, and to briefly indicate the general disturbances which characterize it, for the lesions of the liver are numerous; of very various kinds; often latent at the beginning, during their entire course, and even when they are in an advanced stage; and finally are manifested by a sufficiently complex set of symptoms. Nevertheless it is correct to say that they more especially affect the functions of the digestive and circulatory apparatus, and that they interfere with nutrition by the changes produced in the quantity and quality of the blood.

Each distinct hepatic lesion (chronic congestion, atrophic or hypertrophic cirrhosis, fatty or amyloid degeneration, syphiloma, lithiasis, biliary retention, cancer, cystic disease), evidently acts after its own manner and with more or less intensity upon nutrition, digestion, the peripheral or cardiac circulation, and the composition and genesis of the blood. But from the point of view which we occupy, that is to say as far as concerns the relations of affections of the liver to injuries, the differences are not as marked as might be believed. In fact, in autopsies upon individuals suffering from hepatic disease, who have succumbed from the results of their wounds, the most varied changes have been found: fatty degeneration, cirrhosis, old perihepatitis, amyloid degeneration, lithiasis, cancer, unrecognized hydatids, etc. Everything leads us to believe that when the number of cases shall be increased, less confused results will be obtained; but, at the present time, we are compelled to satisfy ourselves with merely referring to the influence of hepatic affections, taken all together, upon traumatism, and *vice versa.*

In the first place, we may declare, without fear of contradiction, that this influence is generally injurious; that every wound is serious in a patient suffering from hepatic disease; that every such patient is in danger, and that in case of such coincidence, the prognosis is rendered gloomy by each of the two factors in the morbid association. After this statement, if we reflect upon the extreme frequency of secondary changes in the liver; upon its almost inevitable implication by toxic agents such as alcohol, arsenic, and malarial and septic poisons; upon its implication sooner or later when the kidneys, spleen, or heart are chronically affected; upon its almost certain participation in all cachexiæ (tuberculous, cancerous, purulent, etc.); we shall understand what weight hepatism possesses in the question of surgical indications and contra-indications, and we shall wonder that a fact of such gravity should have for so long a time remained unrecognized.

The chief complications observed in these patients, at the region of the wound, are: inflammations of bad character; bronzed, erysipelatous, and diffuse phlegmons; sphacelus; wandering erysipelas, and, as a natural consequence of these local complications, grave traumatic fevers, septicæmia of an adynamic form, and pyæmia following a rapid course; secondary arterial, venous, or capillary hemorrhages are especially to be dreaded on account of their frequency and gravity, and the slight efficacy of ordinary hemostatic measures. The blood, moreover, does not flow through the wounded vessels only, but also escapes at a distance through the nasal and intestinal mucous membranes. Independently of these acute and serious accidents, we also find in these patients that the wound assumes a bad appearance, remains atonic

and languishing, furnishes an abundant but serous and fetid pus; that, in a word, it presents no tendency to cicatrization. I have several times observed this torpid process in the anal region, even when there was no tuberculous lesion present in the lung.

The wounds, however free they may themselves be from any unusual phenomena, may react directly upon the pre-existing hepatic affection, causing, for example, the reappearance of jaundice, biliary colic, anasarca, ascites, obstinate vomiting, and anorexia, profuse diarrhœa, etc. Under this disastrous influence, a patient with hepatic disease who yet has been in a passable condition and threatened by no immediate danger, may soon enter into the period of cachexia, and finally succumb at the end of a few weeks or months. But the disturbing action of the traumatism may be still more rapid and terrible. Thus we may find a patient who suffers from cancer of the liver, cirrhosis, or biliary lithiasis, sinking, shortly after an injury, into a vague condition, bearing no name, and without any well-defined symptoms, and die in a few days, precisely as those do who are wounded while suffering from albuminuria or diabetes.

The probabilities of the appearance of local complications, or of the reciprocal action of the injury upon the hepatic condition, can in no wise be determined from the nature or gravity of the injury. Life has been seriously threatened or even destroyed almost as often in consequence of slight injuries (leech bites, paracentesis abdominis, opening abscesses, simple fractures and dislocations), as after serious operations or grave wounds (compound fractures, severe contusions, herniotomy, castration, amputation, removal of tumors).

Nephrism.—This is the general condition observed in patients suffering from a grave renal affection, whether old or recent. This condition may be acute or chronic, temporary or prolonged, latent or revealed by more or less evident symptoms, among which the character of the urine occupies the chief rank.

The part played by the urinary secretion in the depuration of the blood enables us readily to understand and, to a certain extent, foresee, the changes undergone by the nutrient fluid when the renal parenchyma does not fulfil its eliminating function. Nephrism is very like cases of blood-poisoning, with this difference, that the poison here does not come from without but from within, manifesting its effects as soon as it accumulates in the mass of blood, and making an effort to escape through complementary channels. At the same time that they prevent the necessary expulsion of superfluous and injurious matters, certain renal lesions also permit the spoliation of the blood by the untoward escape of useful substances, as is the case, for example, in albuminuria. The blood, thus adulterated or impoverished, is ill-fitted for the nourishment of the tissues; the poison, seeking unusual channels of escape, affects the various organs, so that, at the end of a certain length of time, there is a true disease *totius substantiæ;* the digestive functions are lowered, the heart is affected, the peripheral circulation embarrassed; the blood escapes from its channels, and serum accumulates, especially in serous or connective tissue spaces. Finally, the nervous centres themselves participate in the disorder.

Renal affections, which are numerous, do not all produce nephrism with the same rapidity or intensity, but eventually, if persistent, they all end by ruining the organism. Generalized, interstitial or parenchymatous nephritis, hydronephrosis, and cystic degeneration, are especially grave; then follow renal lithiasis and pyelonephritis; and finally fatty and amyloid degeneration. From a surgical point of view, however, we may repeat what has been said above with regard to affections of the liver, that is that we are not in a position to say which form of nephritis, for example, most seriously complicates

injuries, and, in its turn, receives from them the most disastrous aggravation. We must restrict ourselves to the statement that the coincidence of an injury and a renal affection (even if but slightly serious) gives occasion for a very unfavorable prognosis.

The local complications of wounds in these cases are very similar to those which have been observed in patients suffering from hepatic diseases. Thus we note secondary hemorrhages, diffuse inflammations of the connective tissue or lymphatics, severe erysipelas, sphacelus, osteo-myelitis, pyæmia, and, as less serious complications, persistent œdema, extreme slowness of the reparative process, interminable serous suppuration, a puffy, bleeding, grayish appearance of the granulations, etc. The bad appearance of wounds is especially noticeable when they affect tissues which have been already infiltrated, as occurs in cases of albuminuria. To these unfavorable conditions of the traumatic centre are naturally superadded general phenomena, and especially more or less active fever, often accompanied by chills. Such symptoms must not always be attributed to the existence of pyæmia. In fact, the attack which makes us fear the invasion of this terrible complication may be simply of renal origin; that is to say, produced by the reaction of the injury upon the pre-existing disease of the kidneys. At the approach of death, it is not rare to find a very marked fall of temperature.

If local complications of wounds carry off a certain number of patients with renal disease who have been wounded or operated upon, death occurs perhaps still more frequently from the inverse action; that is to say, from the rapid or progressive aggravation produced by the traumatism in the pre-existing renal lesions. Among operations, we must particularly mention those performed on the urinary apparatus itself, such as lithotomy, lithotrity, and urethrotomy, and also the incisions rendered necessary by hemorrhagic or urinary infiltrations. If we suppose them to have been properly performed, and the after-treatment judiciously conducted, these operations are benign when the kidneys are sound or but slightly changed; but things are very different when any form of nephritis is present. The mortality then becomes considerable; those operated upon usually succumb in a few days with the general lesions which characterize the last stages of renal affections abandoned to themselves, to wit, diffuse inflammations, gangrene, serous effusion into the pleural and pericardial cavities, pulmonary œdema, and uræmic accidents, such as coma, dyspnœa, eclampsia, etc. Peripheral wounds and operations may also lead to rapid death, even though the seat of traumatism does not appear abnormal; but the progress of the complications is usually less violent; a latent albuminuria becomes evident or is aggravated; nephritis declares itself, with fever, dyspeptic disorders, vomiting, dryness of the tongue, etc.; anasarca appears or becomes more extensive. All may then do well; but it is not rare to find that the renal affection thus excited assumes a progressive course, and increases continually until it produces death, a longer or shorter period after the healing of the wound.

An injury has more than once given rise to the first appearance or sudden return of nephritic colic. Traumatisms affecting certain regions of the central nervous system have produced albuminuria and polyuria, usually, however, only temporary. Wounds of the kidneys themselves are serious when they give rise to oliguria, and especially to anuria; for these symptoms, though accidentally produced, imply a condition of the economy which is as serious as if they resulted from an old renal lesion. We shall not thoroughly understand the reciprocal influence of injuries and of nephrism until it shall have been demonstrated that all wounds modify the composition of the urine, that every modification of the urine implies a corresponding change

in the composition of the blood, and that this modification may in certain cases act upon the reparative process.

Cardism.—Even severe disturbances of the central circulation do not derange the course of the reparative process, if they are temporary. On the contrary, valvular lesions and degenerations of the muscular tissue of the heart may, by changing the static and dynamic conditions of the entire circulation, modify the chemical composition of the blood, cause impairment of important viscera like the liver or lungs, alter the connective tissue which is so necessary to cicatrization, and, in a word, create, locally as well as throughout the entire economy, conditions which are very unfavorable to the proper evolution of the process of cicatrization. Thus passive hemorrhages, either prolonged primary, or early or late secondary bleedings—difficult to check in all cases—have been observed in patients thus affected, together with considerable œdema of the wounded region, and, at the site of the swelling, patches of erythema, of erysipelas, and even of gangrene, such as are met with in all infiltrated tissues, whatever be the cause of the infiltration; and, finally, a local atony which readily metamorphoses the wound into an ulcer, and indefinitely delays cicatrization.

The reaction of the injury upon pre-existing cardiopathies, is still more serious, without reference to the grave, even fatal, attacks of syncope which may follow immediately upon the injury. It is very frequently found, in cases of fatty degeneration of the heart, that the circulation and respiration become embarrassed, and that the wounded person rapidly succumbs, without anything having foretold this termination, and when everything has appeared to be doing well. The catastrophe has been more than once attributed to the effect of chloroform, or to shock, though simply due to the sudden or slow stoppage of an already affected heart. In less severe cases, the traumatism merely reveals cardiopathies which had been hitherto misinterpreted or even ignored by the patients; intensifies the symptoms, especially the anasarca and serous suffusions; and increases the phenomena of oppression, of dyspnœa, by aggravating the secondary disturbances on the part of the lungs.

We possess but little information in regard to wounds in individuals suffering from *aneurisms of the aorta.* I nevertheless know of the rupture of an aneurismal sac (the existence of the blood-tumor not having been previously suspected) in consequence of the simple puncture of a hydrocele. Operations are often performed upon limbs affected by *arterial atheroma*, and it is said that secondary hemorrhage is to be apprehended in such cases. This assertion does not appear to be well demonstrated, and there is much more reason to fear gangrene, in cases of contused wound, or complete or partial sloughing of the flaps of an amputation. There is also danger of a complication which is perhaps even more grave; starting from the injured point, the vessels become inflamed, and an acute endarteritis descends towards the periphery and mounts to the endocardium, producing all those consequences which can readily be foreseen.

Locomotor Ataxia and Various Neuroses.

This disease, which affects the nutrition of certain tissues, chiefly the bones, predisposes on this account to fractures and to those peculiar atrophies of the epiphyses, the point of departure of which is sometimes found in external violence. Some facts also tend to prove that cicatrization progresses slowly or imperfectly in the wounds of ataxic patients.

The reciprocal influence of traumatism upon ataxia is better established.

In the first place, wounds which involve the spine directly and the spinal cord indirectly, readily give rise to chronic myelitis, the symptomatology of which is very like that of ataxia, in certain cases. It has been asserted that wounds affecting the limbs, that is to say at a distance from the spinal cord, may also give rise to ataxia. This is doubtful, and it is much more probable that the violence merely plays the part of an exciting cause giving rise to the premature appearance of the phenomena in predisposed subjects. At all events, there is no doubt that ataxia is usually exaggerated and aggravated by injuries, whether or not they affect the region of the spine. It has been held that certain operations favorably modify or even cure ataxia. But this is a mistake; this affection has been confounded with nervous disorders of reflex origin, which have been relieved by removing the point of peripheral departure. Injuries sometimes present, in neuropathic individuals, a defective evolution and numerous local complications; analgesia, hyperæsthesia, simple or hemorrhagic congestion, lesions of the granular membrane, delay in cicatrization, etc. As a result of wounds of nerves, and of limbs formerly affected by infantile or other forms of paralysis, superficial or deep ulcerations are found to occur, which are attributed to trophic disturbances, and which are at all events very painful and extremely difficult to heal, especially in winter. Reciprocally, in the same neuropathic patients, an injury may excite, revive, or exaggerate nervous manifestations which assume the strangest forms, and which attack the central and visceral nervous systems, as well as general motion and sensation.

Among defined neuroses, *hysteria* and *epilepsy* present close relations to traumatism. In addition to the fact that they sometimes seem to be directly due to injuries, affecting especially the genital apparatus in woman, and the brain in both sexes, it is certain that wounds of the most diverse character as regards situation and extent, have the power of exciting hysterical or epileptic attacks, often indeed with extreme violence. On the other hand, we find mention made by authors of more than one case of epilepsy cured by an accidental wound or by premeditated operation. There has been considerable discussion as to whether *insane* persons tolerate wounds better or worse than other individuals, and the most contradictory facts have been adduced in regard to the matter. The fact is that it is impossible to class together the subjects of mania and those of dementia; those who are excited, with the victims of general paralysis; those whose brains are affected by alcoholism and those affected by old wounds. With such a variety, it is neither possible nor useful to attempt a generalization; and a detailed investigation would not be in place in a work of this character.

Diabetes Mellitus.

All are agreed concerning the unfavorable course of wounds and the gravity of operations in diabetic patients. The reparative process is often absent, or at least very slow, and interrupted by numerous complications. In open wounds are noticed primary capillary hemorrhages, which are difficult to arrest, and also secondary hemorrhages; in contused wounds, diffuse inflammation, bronzed phlegmons, and extensive sloughing. Insignificant wounds such as punctures and excoriations, become inflamed and provoke lymphangeitis, erysipelas, and phlegmons which become complicated by gangrene *en masse* or in isolated patches, and the progress of which is with great difficulty arrested. Slight operations, followed by immediate union, have often presented similar complications. Even the moderate pressure of an apparatus has produced circumscribed gangrene of the skin. Subcutaneous wounds are

less serious, but fractures unite with great difficulty. Diabetic phlegmon and gangrene sometimes progress slowly and without provoking any very violent or grave general symptoms, but they none the less terminate in death, in the majority of cases, especially in old persons whose internal organs are in a bad condition, and when suitable treatment has not been employed in time. Traumatism affecting the region of the medulla oblongata, either directly or indirectly, may, as is well known, produce glycosuria which is usually of short duration, and which undergoes spontaneous cure.

Wounds affecting a diabetic subject generally aggravate his condition. The sugar, which had disappeared, shows itself again, or becomes more abundant. This is especially observed in operations upon those who have been previously recognized as diabetic, and in whom the sugar has been made to disappear from the urine. This return of glycosuria may be temporary, but it may also hasten the development and natural termination of the disease. Wounded diabetics may recover, but they may die in several ways; in the first place, from inflammatory or septic complications which have started in the wound; then of complications on the part of the brain, heart, or lungs; and finally they may rapidly die in a sort of adynamic condition which we cannot attribute to any well-defined local or general complications. The gravity of the prognosis is greater as the wound or operation is more serious, as the quantity of sugar is larger, and as the diabetes is accompanied with more advanced visceral lesions.

The distinction established by modern writers between glycosuria and diabetes is admissible to a certain extent, but we must not trust to it too much, and regard as benign those wounds which occur in individuals who pass but little sugar. It is equally incorrect to regard as favorable the substitution of albumen for sugar in certain diabetics. Except in urgent cases, we should never operate upon a diabetic patient, until we have made the sugar disappear as much as possible from the urine.

Alcohol-diabetes.—Although it has not yet been referred to, the association of alcoholism and diabetes cannot be very rare, if we take into account, on the one hand, the polydypsia natural to diabetics, and, on the other, the advice given these patients to take stimulating drinks. As poisoning by alcohol and poisoning by sugar both give rise to quite similar complications in the traumatic centre—diffuse inflammation, erysipelas, gangrene—it is not surprising to find that in the subjects of alcohol-diabetes, wounds, which were at first slight, are followed by serious and rapid complications. Thus, I have seen a puncture or contusion cause very extensive sloughing, and catheterization give rise to double, rapidly fatal nephritis. While an autopsy often gives negative results in cases of simple diabetes, in those cases of alcohol-diabetes which I have seen, grave visceral lesions have been noted—cirrhosis, old perinephritis, double nephritis—which were very probably the results of the alcoholism, and which would by themselves have given rise to the fatal termination without the concurrence of the diabetes. More numerous observations will permit further study of this interesting variety of hybrid disease.

Phosphaturia.

Glycosuria is not the only form of diabetes; in the same rank must be placed simple polyuria, or diabetes insipidus; phosphaturia, or phosphatic diabetes; azoturia, and finally uric diabetes, which alternates so frequently with diabetes mellitus. Who knows indeed whether the list will not become more extensive, and whether it will not be necessary, at some future period,

to add the exaggerated elimination of the chlorides, or of any other substances contained in the urine? For the present, I have but little to say in regard to the relations existing between injuries and these various forms of diabetes. In a very large and stout man a slight contused wound of the leg did not heal, and tended to become transformed into an ulcer. Examination of the urine showed that the patient was azoturic to a high degree. On the other hand, a young scrofulous individual passed daily from 12 to 15 litres [12½ to 16 quarts] of urine as clear as water. Disarticulation of the first metatarsal bone had to be performed; it was followed by no complication, and the wound healed without delay or difficulty.

I have collated more abundant and more interesting material with regard to phosphaturia. It has, in the first place, appeared to me to play an important part in fragilitas ossium, and in the spontaneous fractures which occur without previous circumscribed lesions. Certain facts would permit us even to establish relationships between organic affections of the bones and phosphaturia, although it is impossible to decide whether the latter be cause or effect. We will often find an exaggerated elimination of phosphates in cases of polyuria in scrofulous children suffering from osteitis. I have several times observed the disastrous influence exercised by phosphaturia upon the local progress of injuries. I have noted, for example, a consecutive hemorrhage, a diffuse phlegmon, orange-colored suppuration, purulent destruction of the eye after the operation for cataract, marked delay in the union of fractures, etc.

As a sequel to well-characterized maladies, it would be proper to study, in their relations to accidental or surgical injuries, certain temporary states which assuredly are not pathological in the literal sense of the word, and yet during the duration of which, the organism finds itself under peculiar conditions. These states include *dentition*, *puberty*, *menstruation*, *the menopause*, *pregnancy*, *the puerperal state*, and *lactation*. In the opinion of the public, these conditions have a very manifest influence upon previously existing or intercurrent diseases, and it would be very useful to know exactly whether it were the same in regard to wounds. The question of surgical interference, also, arises very frequently in the two extreme periods of life, *infancy* and *old age*. Opinions differ widely as to the course of injuries and the manner in which they are tolerated under these circumstances. Unfortunately we have not sufficient materials to clear up all these problems; we barely possess a few facts in regard to pregnancy and the puerperal state, and to operations in childhood and old age. I give here a brief summary of what is known to science upon these subjects.

Pregnancy.

This question was debated at length in the International Congress of Geneva, in 1877. It was established that pregnancy and traumatism may run their course parallel to each other in a normal manner, without influencing each other in the slightest degree, even when the injuries are extremely severe; that pregnancy may disturb the reparative process by delaying or hindering healing, and by giving rise to various wound-complications at the injured point; it may also aggravate certain non-traumatic affections in such a manner as to render necessary and even urgent, operations which, in the non-pregnant condition, could have been avoided or postponed. The delay or hindrance in the healing of wounds, which is produced by pregnancy, may cease immediately after delivery, which restores to the reparative tendency all its power.

Accidental or operative wounds, even the slightest, may interfere with

gestation in several ways: by provoking abortion or premature delivery; by causing the death of the mother with or without that of the child, and either before or after that of the child.

The normal termination of the pregnancy, that is to say the reciprocal independence of the traumatism and of the pregnancy, may be foreseen and announced: when the wound is remote from the genital apparatus; when it affects healthy tissues; when it is slight, simple, and not complicated primarily or consecutively by any accident capable of transforming the wounded person into a sick one; and when, on the other hand, the uterus, the fœtus, and its annexes, are anatomically and physiologically normal, and when the maternal organism, which has been suddenly subjected to the injury, is sound or nearly so, that is to say free from all constitutional disease existing either before or after fecundation, and when it remains so afterwards.

The injurious influence of traumatism upon pregnancy and the various terminations which follow, may, in turn, be foreseen and declared: when the wound affects the fœtus and its annexes, the uterus, and the other organs pertaining to the genital sphere, and when these parts are, in advance, altered in various ways; when the wound is extensive or grave in itself, or when it affects organs essential to the life of the mother; when the mother has suffered, before the reception of the wound, from a constitutional morbid condition, or from a circumscribed affection which renders abortion possible and probable; or when some complication starts from the wound or its immediate neighborhood, and is at all events capable of weakening, shattering, or poisoning the maternal or fœtal organisms.

We may hope for and declare the favorable, though indirect, action of surgical traumatism upon pregnancy, when, by the aid of even a serious operation, we can succeed in removing an affection which is still more dangerous to mother and child.

The aggravation of certain morbid conditions in the pregnant woman is explained by the general or local modifications which pregnancy produces in the circulation, in nutrition, in the composition of the blood, and in the genesis of anatomical elements; and in the same manner is explained the favorable action of delivery, which suppresses various pathogenetic causes. We can understand the hurtful effect of the puerperal condition upon traumatism contracted after delivery, if we take into consideration the conditions then presented by the injuries which, in fact, often involve tissues that are altered, or profoundly modified in their structure and properties; individuals already wounded by the mere fact of the uterine trauma; women already sick in consequence of pregnancy itself or of the constitutional conditions which may be associated with it. Whenever a woman, during the period of fecundity, is wounded accidentally or as the result of a surgical operation, we should always determine whether she is in a condition of pregnancy or not. In the former event, we should note with extreme care, immediately after the injury or before the operation, the organic conditions of the mother, the state of her genital apparatus, and that of the product of conception. In case of an accidental injury, the local and general treatment should be directed to moderating or preventing the direct or indirect, disastrous effects of the wound upon the genital apparatus; to maintaining the patient in, or restoring her to, the condition of one who is simply wounded, and to prevent her from being changed into one who is sick; to palliating or combating every injurious effect of pregnancy upon the reparative process; in a word, to preventing abortion.

When abortion occurs, we should watch the wound to ward off any possible aggravation, and the uterus to prevent the septicæmia of which it is sometimes the starting-point and the seat.

Surgical interference is not interdicted during pregnancy, but is subject to special rules. We should operate upon a pregnant woman with the greatest reserve, and sometimes refuse absolutely; but it would be an equally grave fault to abstain systematically in all cases. The affections which are amenable to operation—more numerous during gestation than during the non-pregnant state—are divided into several categories which suggest the following rules of practice:—

To operate at once in those affections which immediately endanger the life of the mother, and against which medical treatment would be certainly or almost certainly unavailing;

To operate also, at a suitable time, and after having tried palliative or curative remedies, in those diseases which, although not immediately compromising life, endanger it by their progress, and tend to become incurable if not met with energetic treatment;

To operate also in those affections which, without disturbing pregnancy and without being aggravated by it, become, at its termination, causes of dystocia. In these cases, the surgeon may operate before or at the very period of delivery, upon the mother or upon the fœtus, the premature expulsion of which may be induced. An attempt should be made to save both the maternal and fœtal lives, but, if this be impossible, the latter must be unhesitatingly sacrificed to the former;

To abstain, as far as possible, in those affections which are uninfluenced by pregnancy—and which, in turn, only compromise pregnancy and parturition indirectly—by, as far as possible, allowing nature to act, and by aiding her by mild measures;

To abstain absolutely from every operation for affections which compromise only the form or function of organs of secondary importance, or which are susceptible of spontaneous cure after delivery;

To avoid, as far as possible, every operation during the puerperal state. In case of danger, to operate rather during pregnancy, and, under opposite circumstances, to postpone interference until a period sufficiently remote (two to four months) from delivery.

Infancy.

The benignity of wounds and surgical operations in children is universally admitted, and the explanation, moreover, is simple. In fact, at this period of life, constitutional diseases are not deeply rooted, but of recent date; the viscera are for the most part healthy; and connective-tissue proliferation and regeneration of tissues occur with promptness and energy, etc. We must not, however, regard this benignity as a rule without exceptions. Athrepsic children, poorly nourished, syphilitic, or tubercular, or who suffer from calculus with nephritis, readily fall a prey to the consequences of their wounds.

In this long period of childhood, moreover, we should establish categories according to the age, and consider also the particular variety of operation which is in question. The new-born, for example, support loss of blood and restricted diet very badly; and the resulting contra-indications continue at least until the twelfth or fifteenth month. It is for this latter reason that we postpone until the fourth or fifth year, if not later, complicated operations upon the mouth, lips, hard or soft palate, etc. The small size of the parts also relegates to the period of late childhood certain anaplastic operations upon the penis and fingers. Finally, we wait still longer before undertaking the cure of certain imperforations in the female sex.

Old Age.

Some old people, whom we should rather call aged than old, tolerate traumatic lesions as well as adults. In others, on the contrary, the reparative process remains imperfect. Interstitial wounds suppurate; immediate union fails; local inflammations do not remain circumscribed; gangrene attacks the detached and thinned integument; simple fractures unite slowly; severe contusions are complicated by diffuse phlegmon and sloughing. At other times, the seat of traumatism remains indolent, without tone, and languishing; but threatening internal inflammations are set up; pneumonia, nephritis, meningo-encephalitis declare themselves, followed by their train of general adynamic or ataxic symptoms, and death promptly ensues. The autopsy almost always reveals a previously existing bad condition of the great viscera, which entails the same consequences as in adults. In individuals who are apparently healthy despite advanced age, the organs have sufficed for the needs of a regulated and tranquil life; the traumatism occurs, gives a shock to the economy, stirs up old morbid susceptibilities, and destroys an organization which has only maintained itself in equilibrium, as it were, by accident.

GENERAL PRINCIPLES OF SURGICAL DIAGNOSIS.

BY

D. HAYES AGNEW, M.D., LL.D.,

BARTON PROFESSOR OF SURGERY IN THE UNIVERSITY OF PENNSYLVANIA, SURGEON TO THE PENNSYLVANIA HOSPITAL, PHILADELPHIA.

Operative Medicine must be based on exact knowledge. The cunning of the hand can be safely directed only by the wisdom of the head. To be able to discriminate, with accuracy, the various morbid conditions of the human body, is the highest qualification of a physician. Such knowledge can only be attained by large experience, by habits of close observation, by the ability to logically dispose of, or classify, phenomena, and by the possession of a sound judgment. In the formulation of phenomena gleaned from the domain of physics, the student is concerned with matter alone, the behavior of which is, under like circumstances, uniform. The physician also has to deal with material forms, but these forms are instinct with life and intelligence, factors which necessarily render the problem for study vastly more complex and more difficult of solution. It is, consequently, no easy task to accurately interpret the phenomena of disease, and to ascertain with absolute certainty its true nature; and yet it is only when such knowledge has been obtained that the physician or surgeon can safely venture to administer remedies or to counsel operations.

The diagnostician, to be properly equipped, must have cultivated an extensive domain of study. Anatomy, Physiology, Pathology, Chemistry, Physics, and Mental and Moral Philosophy, constitute the foundations of diagnostic knowledge.

In pursuing the investigation of surgical disease, two methods are practised, namely, the *analytical* and the *synthetical*. By the first, the surgeon commences his inquiries at the origin of the affection, and traces it down to the time of the investigation; by the second plan, the examination commences with the present phenomena, and follows them back to the beginning of the disease. Generally the first or analytical method is pursued, although the latter, or synthetical, will, in certain instances, be found preferable.

The examination will, in the largest number of cases, be most successful when it is introduced by eliciting a general history of the complaint, and afterwards obtaining particulars. Such a course is less embarrassing to the patient, and tends to establish the practitioner in his or her confidence. The obscurity which attends some cases may require that both the analytical and the synthetical methods shall be employed, and even then, it is not impossible that the secret of disease may defy and baffle the tactics of the wisest diagnostician.

Whenever the surgeon is compelled to abandon certitudes, and to base his opinion on probabilities, he is on dangerous ground, and should either advance cautiously or not advance at all; the latter course should, by all means, be adopted when there is no urgency for active measures to be taken. A few

hours' delay will often clear away all obscurity, and render perfectly plain problems which were before insoluble.

Difficulties in Surgical Diagnosis.

The difficulties which environ the investigation of disease, arise from several sources. Among these may be mentioned the reluctance with which many consent to communicate any information calculated to affect unfavorably the social or physical standing of themselves or those who may be related to them by consanguinity. This difficulty can be overcome only by the personal tact of the surgeon. In this matter there exist very great differences among practitioners. Some men, either from constitution or education, are unfortunate in never being able to secure the entire confidence of a patient, while others, more favored, by a kind, sympathetic manner, an insinuating address, and other amenities which impart a loadstone attraction to character, will, in a few minutes, obtain such a mastery over the will and the affections of the patient, that nothing will be withheld. There are also constitutional peculiarities and idiosyncrasies, which impart to the phenomena excited by morbid impressions unusual characteristics, altogether dissimilar to those developed in most persons under the operation of like causes. The similarity of the morbid phenomena, which may result from diseases altogether unlike, constitutes another source of embarrassment, as do also the wide range of sympathy which prevails in the human body, and the reflex impressions which tend to disguise their original source, thus diverting the attention from the real to the unreal.

The interrogation of a patient, like that of an unwilling witness in a court of justice, requires considerable skill. Sometimes it is desirable to allow the patient to narrate the history of his own case, provided that he adheres strictly to the subject of inquiry, and does not wander off into useless digressions, or matters altogether non-essential. A license of this kind will often disclose peculiarities of character which will prove of value in the general estimation of the case.

Questions should be put in plain words, free from all ambiguity and from technical terms. The answers of the patient should be as brief and concise as possible, or as may be consistent with furnishing the desired information. In order to secure exactness and brevity of statement, no leading or suggestive questions should be asked. Undue levity of manner, either in interrogation, or as excited by the language used by the patient, is to be deprecated. Such a manner is calculated to wound the sensibilities of the sufferer, and lays the profession open to the charge of being unfeeling. It is not to be expected, that the uneducated should describe their sensations in grammatically constructed sentences, or in the most fitting words.

When it becomes necessary to question women on matters of a private nature, the inquiries should be framed in the most delicate language, and should never be pressed beyond the strict bounds of propriety, or from motives of curiosity. With young women, much embarrassment is avoided by addressing the questions, and obtaining the answers, through a mother or elderly friend, rather than directly to and from the patient.

The influence of disease in changing the *morale* of the sick must never be forgotten. Under morbid influences, the most amiable character may be transformed into one which is fretful, irascible, or morose; and hence the necessity on the part of the surgeon of making due allowance for deportment which, under other circumstances, would be regarded as uncivil and inexcusable.

Unless absolutely necessary, no exposure of the person should be made in conducting examinations; nor should the use of instruments be repeated oftener than the nature of the case demands. In fine, the strictest formality and absence of familiarity ought to be maintained between the surgeon and his patient, alike with the poor and unlettered, as with the rich and cultured.

In the examination of a case, whether medical or surgical, the inquiry will be both general and special. In the former, or *general examination*, the questioner endeavors to obtain, from the patient or his friends, a history which will include the particulars of age, sex, social condition, habits, occupation, residence, family antecedents, etc. The *special* inquiry will be confined to obtaining such information as may be learned by a personal examination.

General Examination: History of the Case.

Age.—The influence of age in giving shape to surgical inquiries, and in solving the problem of disease, is very important. The notable irritability of the nervous system in childhood and adolescence, impresses a peculiar physiognomy on most of the affections belonging to infantile life. For example, the irritation of a resisting gum, in dentition, may be reflected to the remotest parts of the body, and may cause the most disorderly and spasmodic action of the entire muscular system. Such phenomena, when occurring in an adult, would be referred to an entirely different source, and would excite apprehension of a much graver state of things than when the subject is a child. A pain in the knee, in a child, would immediately direct attention to the hip-joint. Abdominal pains and grunting respiration would suggest the possibility of disease of the vertebræ. Cervical enlargements, which in the adult probably would be regarded as cysts, carcinomata, or sarcomata, would in the child be construed as adenomata.

Vesical irritation in children suggests the presence of urinary calculus, while in a person advanced in life, the same symptoms would be referred to cystitis or to an enlarged prostate. In lesions resulting from violence, affecting the extremities of bones in children, the probability of a separation of the epiphysis, an accident which could not occur in an adult, would necessarily enter into the consideration of the case. A force which in a young adult would cause a fracture at the upper end of the femur, external to the capsular ligament, would be likely, in an individual over fifty or sixty years of age, to produce a similar lesion within the joint. Finally, the diseases peculiar to childhood are the different exanthemata, as scarlet fever, measles, etc.; inflammatory affections of the upper part of the alimentary and respiratory passages—as, for example, tonsillitis, diphtheria, laryngitis, and tracheitis—are also common in youth. In middle life, inflammatory attacks affecting the thoracic, abdominal, and cranial viscera, are most commonly met with; while in advanced life, the characteristic maladies are such as affect the genito-urinary organs, or cause structural degenerations in the bloodvessel system.

Sex.—There exists such a radical difference between the physical and psychical nature of the two sexes in health, that it is reasonable to expect that their peculiarities should be intensified under the perturbing operation of disease. In the moral constitution of women, the emotional element preponderates, and in the physical organization, the sexual system. The reaction of the latter on the former imparts a coloring to all morbid phenomena—hence the hysterical convulsions, hysterical joints, fictitious blindness, irritable bladder, etc., which are encountered during the active period of the uterine

and ovarian functions; while after the climacteric has been passed, woman often becomes the prey of those horrid fibroid and carcinomatous neoplasms which attack the uterus and the mammary glands. Men, on the contrary, enjoy a singular exemption from hysteroidal attacks, as they also do from carcinoma. If a man complains of uneasiness or pain in a joint, it is generally real—rheumatic, gouty, or symptomatic of some other form of inflammation—and not a mimicry of disease; if a limb suddenly loses its power, the paralysis is real, and not a simulation; if an irritable bladder is developed, there is a reasonable certainty that there is a true physical basis for the disturbance, such as stone, cystitis, or an enlarged prostate. Should he become the subject of cancer, the disease will most likely prove to be of the epithelial variety, and will probably be seated on the lip or in the rectum; and if he is seized by a convulsion, epileptic or otherwise, the idea of central or cerebrospinal lesion will be naturally entertained.

Both sexes furnish examples of cardiac derangement. In the male, they are not often present unless some structural change has taken place in the heart and bloodvessels, such as valvular disease, atheroma, or aneurism; while in the female, they are quite as frequently the result of reflex irritation. Hernia is met with in both sexes; but while inguinal hernia largely outnumbers all other varieties in the male, in the female sex, the femoral variety is very common. While, however, in the main, the portrait which has been drawn is a true one, yet the surgeon must never assume, without a most critical and exhaustive investigation having first been made, that, because the patient is a woman, certain symptoms have no real or substantial basis. Indifference to this caution has cost many women their lives, the disease having been unrecognized until too late to admit of a remedy.

Occupation is not only a fruitful cause of disease, but determines in many instances the nature of the morbid process. The worker in a manufactory of lucifer matches, provided that a defective tooth exists in the jaw, is prone to suffer from phosphor-necrosis of the maxilla. The painter becomes the subject of lead colic; the chimney-sweep, of soot-cancer of the scrotum. Persons who are employed in the manufacture of chemicals, who are constantly exposed to contact with irrespirable gases, or who are habitually engaged in sand-paper and glue establishments, not infrequently fall victims to serious disease of the air passages and lungs. The house-maid, some of whose duties require her to be much in the kneeling posture, is liable to have an enlargement of the patellar bursa. Plumbers and other persons whose occupations call them to labor in damp or wet localities, such as ditches, drains, etc., are peculiarly predisposed to rheumatism. A particular occupation or trade may produce such alterations in the form or symmetry of the body as, if not understood, would be apt to create much unnecessary apprehension in the mind of the surgeon. Thus, the shoemaker or the tailor, toiling day after day over the lap-stone or the lap-board, becomes round-shouldered, and finally gets a curved spine, or changes the form of his breast; while the boy who is constantly engaged at the lathe, destroys, by the habitual use of the same foot, the bilateral symmetry of the lower extremities.

Habits.—The influence of *habit* not only constitutes a powerful element in the production of many of the affections of the body which become the subjects of medical or surgical attention, but, when recognized, materially modifies prognosis, and explains phenomena which otherwise would be exceedingly obscure. Thus we have defects of vision which are induced by the excessive use of tobacco; except for the knowledge of the existence of this practice, the appearances of the eye would excite serious apprehension for its future. The

same habit, not infrequently, is instrumental in producing follicular pharyngitis, but the prognosis will be very different in a case of this nature arising from smoking, and in one symptomatic of pulmonary disease. The surgeon's opinion in regard to a sore on, or a discharge from, the male or female genitalia, will be influenced in no small degree by the known purity or depravity of the patient. But, on the other hand, a chaste and virtuous young woman, or an innocent wet-nurse, may suffer unjustly in character, the one having been infected by an impure kiss from a lover whose lip bears a syphilitic crack, and the other by suckling a syphilitic child. In childhood, a prepuce elongated by habitual traction with the fingers, at once excites the suspicion of either stone in the bladder or the existence of a tight phimosis. Sexual weakness, when ascertained to be the result of venereal excess, assumes a very different importance from that which it possesses when induced by the oxalate of lime diathesis, or by spinal concussion.

Antecedent History.—This embraces a history not only of the past life of the patient, but also of that of his ancestors. Nothing is better established than the transmissibility of disease. It is much more likely to abide with the children, than the wealth which they inherit. Singularly enough, it sometimes happens that morbid legacies will skip a generation and appear in the succeeding one, although such cannot be said to be the rule. The value of a knowledge of antecedents in imparting certainty to diagnosis, is incalculable. A patient who in the past has been the victim of syphilis, and who, after probably the lapse of years, is attacked with pains in the course of certain bones, will demand a different kind of treatment from that proper to a case of idiopathic rheumatism; and the same will be true of an iritis arising from a similar cause. There are many instances of persons who exhibit symptoms of pulmonary disease, but in whom no detectable lesion exists. The physician may be in doubt as to the necessity of a change of climate, but if it be shown that a maternal or paternal ancestor has died of tuberculosis, that doubt will be immediately solved and the change advised. A pain in the knee or in any other articulation of a child, awakens much more anxiety when it is known that there is an antecedent history of tubercular disease; and so in the clinical investigation of obscure tumors, the diagnosis is influenced in no small degree by what can be learned with regard to the physical soundness or unsoundness of ancestors and other relatives.

Personal History is no less important than a history of antecedents in interpreting morbid phenomena. In this is comprised a knowledge of constitutional peculiarities. An individual possessed of a *sanguine* temperament, as manifested by the possession of a strong and vigorous heart, a full and bounding pulse, a florid complexion, a warm surface, and the other signs of a dominating vascular system, is one predisposed to acute inflammation of different organs. Apprised of such a constitutional predisposition, the surgeon will be ever on the alert, anticipating these complications, and prepared to combat them before they have gained strength or have become fully entrenched. The patient may possess a *phlegmatic* temperament, characterized by a dark complexion, a lazy circulation, and obtuse sensibility, with the mental operations and bodily movements alike conducted sluggishly. Individuals so constituted are stolid, indifferent to suffering, and disposed to endure quietly rather than complain by word or other demonstration. Here the tendency, on the part of the medical attendant, is to undervalue the power or severity of the disease or injury, and to be betrayed into a false sense of security while the mischief is underrated or is not detected until too late for successful management. Allowance must also be made for persons

of a *nervous* temperament, those restless individuals with quick movements, whose circulation is easily excited, and who endure pain badly. Their excessive sensibility and easily extorted complaints must be largely discounted.

There is another aspect in which personal, antecedent history should be considered, and which must influence diagnosis. Thus if a joint should suddenly become swollen and painful, the disorder, aside from any previous history, might be attributed to very different causes; but if it were ascertained that, immediately before the occurrence of the trouble, the patient had met with a fall or a violent wrench of the limb, all the phenomena would be referred to a sprain. If it should be known that an attack of epilepsy had been preceded, at some interval, by violence applied to the head, it would not only be logical to refer the convulsion to a traumatic origin, but a knowledge of the fact would be of the utmost value in determining the propriety of operation. In a case of facial paralysis, both the diagnosis and the prognosis would be modified by learning that the loss of power had followed a blow below the ear. A person picked up in a state of coma, and with the smell of liquor on his breath, might be subjected to a damaging and unjust criticism; one which would be quickly recalled if it should afterwards appear that the patient had fallen or been precipitated headlong from his carriage or his horse. In certain cases of convulsions resembling those of tetanus, hysteria, or mania, how much light is shed on the disease, when it is known that the patient has been bitten by a rabid dog! Not infrequently information on some of the above conditions can only be obtained from some person other than the patient himself.

Mental and Moral States.—The influence of the mind and emotions over the functions of the body, is perhaps too often under-estimated. Such influences are notably concerned in causing disturbances of the various secretions. Under the feeling of fear, the action of the salivary and other glands of the mouth and pharynx may be for a time entirely suspended, and the throat rendered so dry that nothing solid can be swallowed. A marked suppression of urine will occasionally occur as a result of great mental anxiety or distress. Profound grief, which no formula of words can express, is often denied the relief of tears, from the operation of the lachrymal glands being completely arrested. The harass and worry of business cares will sometimes beget an irritable bladder. Permanent impotence has been produced by fright. The shock following the communication of unwelcome tidings has developed a heart murmur; and the effects of fear, of remorse, or of disappointment from the miscarriage of cherished plans at the moment of their expected consummation, are always unfavorable to the reparation of surgical injuries. Then there is an ardent temperament, which, when associated with a highly wrought imagination, tends to impart an unreal or fictitious coloring to the disease or injury of its possessor, and is well calculated to mislead the unsuspecting practitioner. Hope is a mighty element in the cure of disease, and it is the duty of the surgeon, whenever he can conscientiously do so, to avail himself of this powerful cordial and stimulus, which constitutes so efficient an antidote to the effects of sickness and injury.

Social Condition.—This will also become a subject of investigation, which should include an inquiry into the state of the patient, whether single or married, active or idle; his sexual indulgences, whether occasional or frequent, lawful or illicit; and, in the case of a woman, the number of her pregnancies, of her miscarriages, and of any irregularities or complications which may have taken place during or after parturition.

Residence.—The influence of local conditions in affecting surgical diseases must not be overlooked. Miasma contracted during a temporary residence in some unhealthy district, will often lie dormant in the system until aroused into activity when the individual is overtaken by some accident. It is, accordingly, a great relief to the mind of the surgeon, if, on the occurrence of a rigor after an operation or injury, it be ascertained that the patient has previously been exposed to malarial influences. The effect of location in impressing certain characters on disease is well seen in the nature of many of the maladies which befall large numbers of our metropolitan populations, whose residences, situated in lanes and alleys, are often damp and badly supplied with either sunlight or air, and who subsist on food the quality and preparation of which render it unsuited to the purposes of nutrition. The propriety of referring to the effect of residence, the ophthalmic, glandular, and other diseases incident to defective nutrition which are usually encountered in persons living in such dwellings and under such surroundings, will be apparent.

Duration of Disease.—The period over which a disease extends, has no small influence in determining the question of its nature. Thus, as regards morbid growths, a tumor which has existed for several years without causing any marked uneasiness, either local or general, will probably be regarded as benignant, while one of a few months' duration, which has rapidly increased in size, will be deemed malignant. There are, of course, some exceptions to this rule.

Special Examination: Knowledge Obtained by Personal Investigation.

Posture or Attitude.—The eye, when educated in the school of experience, will often be able to detect the nature of a disease in the posture assumed by the patient. Incipient coxalgia is disclosed in a flexed position of the limb, in eversion of the foot, and in obliteration of the gluteo-femoral groove; dislocation of the head of the femur on the dorsum ilii will be recognized by the shortening of the limb, by inversion of the foot, and by the salient position of the trochanter major; while in intracapsular fracture of the thigh bone, the nature of the accident will be strongly suspected on seeing the foot lie on its outer side. In acute peritonitis, the inflammation is revealed by the dorsal decubitus, flexed limbs, and distended belly; while in colic, or spasm of the muscular walls of the intestines, the patient will often lie on the abdomen. A child, who, in walking, keeps the body rigidly straight and stiff (Fig. 21), the shoulders elevated and the arms abducted, and who moves with a shuffling gait, furnishes the evidence of spinal caries; as he does also when he squats down instead of bending in order to pick up an object from the ground (Fig. 22). A large, inflammatory effusion into the thorax or into the abdomen, generally necessitates a sitting instead of a recumbent posture. A patient who carries an uninjured arm flexed and supported by the opposite hand, with the head inclined to the damaged side, will probably be found to have a broken clavicle. Sliding down in the bed betokens extreme exhaustion. In all cases in which persons are seen to fix the shoulders, either by resting the hands on the bed or by throwing an arm over the back of a chair, or any unyielding support, difficulty of respiration may be safely predicated. Indeed, almost every disease and injury will betray, to some extent, its nature in the posture assumed by the patient.

External Expressions of Parts.—A correct knowledge of the normal appearance or form of different parts of the body, is of inestimable value to

the physician or the surgeon, as it is only by the possession of such knowledge that he is able to appreciate those deviations which are produced by disease or accident. A flattened shoulder, with a salient acromion process, suggests a luxation of the humerus; a prominence of the spinous processes of one or

Fig. 21.

Appearance of child suffering from caries of the vertebræ.

Fig. 22.

Mode of stooping in a subject of spinal caries.

more vertebræ, indicates the existence of Pott's disease of the spine; the obliteration of the gluteo-femoral fold raises a suspicion of coxalgia; angular deformity in the continuity of a limb reveals a fracture of its bone or bones; a joint, whose surface depressions and elevations have all been merged in a general swelling, is likely to be filled with fluid; and the obliteration of the intercostal depressions, by the bulging of the tissues between the ribs, indicates an empyema or hydrothorax. The form or shape of a swelling will often reveal its exact location. Thus, an enlargement situated under the jaw, the limitations of which are the angle of the inferior maxilla posteriorly, the symphysis of the jaw anteriorly, and the digastric muscle below, will be found to be seated in the submaxillary region; and in like manner, a swelling which is rigidly confined between the spine of the scapula and the upper border of the bone, will in all probability lie beneath the deep fascia and in the supraspinous fossa. As other illustrations under this head, may be mentioned the acuminated form of an abscess, the pyriform scrotum in hydrocele, the convoluted appearance of varicocele, the frown which settles on the brows in peritonitis from the contraction of the corrugator muscle, the sardonic grin in tetanus, the pinched features of the Hippocratic face, presaging approaching dissolution, and the notched teeth in transmitted syphilis, with many others which might be readily adduced.

Information Derived from Touch.—While in most instances the form of a swelling can be determined by the eye alone, yet occasionally it becomes necessary to call into requisition the sense of touch, in order to obtain a correct idea of the exterior of an enlargement. Thus a tumor within the abdomen, or in the neck, or in the groin, may present a uniform surface to the eye, but, when examined by the fingers, may be found to be irregular or lobulated. It is possible, in some cases of extra-uterine pregnancy, to trace the outline of the fœtus through the abdominal walls or through the vagina, and thus to establish the diagnosis. In this way, also, the convoluted form of a varicocele, and the irregularity or knobbed surface of a mammary tumor, will be disclosed. The lenticular form of the inguinal glands, discoverable by the touch, serves to distinguish an adenitis from a hernia.

Independent of the external configuration, we learn, from the touch, the density of tumors and other enlargements—whether liquid or solid, hard or soft, elastic or doughy, fluctuating or tremulous. By tact, also, we recognize the peculiar crepitation or crackling which indicates a collection of air in the subcutaneous connective tissue (emphysema). By the same sense, the crepitus of fractures and the crackling of inflamed bursæ can often be distinguished when their sound cannot be heard; and it is through the touch that the physician measures the force, frequency, and regularity of the arterial pulse.

Weight.—Closely related to the exercise of touch is the estimation of weight. The diagnosis of a tumor is influenced in no small degree by its weight. Disproportion between the weight and the bulk of a morbid growth located in the testis or mammary gland, affords considerable ground for regarding the neoplasm as either a carcinoma or a fibroma.

Mobility is also determined by an exertion of the sense of touch. External growths which admit of being extensively moved are usually superficial; while those which are fixed are, as a rule, deeply situated. In fracture there is preternatural mobility, while in luxation there is unnatural rigidity.

Temperature, although only to be correctly measured by thermometry, may often be estimated by the touch with sufficient accuracy to enable the practitioner not only to form just deductions in regard to the nature of the disease, but to prescribe the proper line of treatment.

Too much attention cannot be bestowed on the cultivation of the sense of touch. It is susceptible of being educated to a degree of extreme delicacy, as is witnessed in the readiness with which, in the blind, it is made to supplement the deficiencies of vision. Many fatal blunders in surgery have resulted from an untrustworthy touch.

Color, also, is to be considered in forming a diagnosis. Thus we have the bright scarlet blush which belongs to acute inflammation; the dusky red which accompanies low forms of erysipelas; the dull red or mottled hue of chronic inflammation, indicating also venous obstruction; the blue or livid color of the lips in some cases of croup, or in asphyxia; and the purple and red intermingled which mark the skin overlying malignant growths. To these may be added the varying shades of color—blue, blue-black, olive, and yellow—which follow ecchymoses or extravasations of blood, generally venous, into the subcutaneous cellular tissues; the black of mortification; the unnatural white of anasarca; and, finally, the sallow and waxy hues which attend advanced cases of carcinoma.

Translucency.—The true nature of many swellings is ascertained by the translucency of their contents. The existence of this condition is revealed by

placing the patient in a darkened chamber, and by supporting the part to be examined between the surgeon and a lighted taper or candle, the hand at the same time being placed vertically above the tumor in order to intercept the upper rays of light, which otherwise would confuse the vision. A less satisfactory mode of demonstrating translucency, which may be practised by sunlight, consists in using a hollow cylinder of paper, one end of which is placed on the swelling while the eye of the surgeon is applied at the other end. It is in this way that, either by artificial illumination or by sunlight, we are enabled to recognize a hydrocele, a spina bifida, and various forms of cyst.

Mensuration.—The measurement of parts also serves to enlighten diagnosis, the standard of reference being, in the case of the extremities, the corresponding sound limb. The metallic or the linen tape-line, accurately graduated, is best adapted for obtaining measurements. In cases of fracture and of dislocation, a resort to mensuration is often necessary before any reliable conclusion can be reached. Much care is required to render this mode of investigation valuable. For example, in applying the tape-line to the lower extremities, the patient should be laid on a level, unyielding surface; the limbs placed side by side; and the body in an exact line with the extremities, so that the pelvis shall not incline to the right or to the left. Any deviation from this position will so vitiate the measurements as to render them nugatory and unreliable. It is also necessary that the measurements shall be made between points of the skeleton which are stable and unvarying; in the lower extremities, from the anterior superior spinous process of the ilium or the spine of the pubic bone above, to the internal malleolus below; or, in case of dislocations of the coxo-femoral articulation, from the anterior superior spinous process of the ilium to the trochanter major and the tuberosity of the ischium. In the upper extremity, the points of reference, in fracture of the humerus, are the acromion process of the scapula and the condyles of the humerus; and, in elbow dislocations, the condyles and the olecranon process of the ulna.

By the tape-line, any irregularity between the two sides of the thorax, such as is likely to occur in effusions into the cavity of the pleura, can be determined, as can also the growth of an ovarian cyst or the enlargement of a dropsical joint. Deviations of form from the perpendicular can be easily determined by the plumb-line. When it is desired to obtain an exact transcript of the angles or curves of the vertebral column, this can be done either by laying over the spine a malleable metallic ribbon, and pressing it into the irregularities, or by running up and down the vertebræ two or three times a wet plaster-of-Paris roller, and, after it hardens, removing it from the back, when it will be found to retain the exact shape of the column.

Sound.—Through the educated ear, the physician and the surgeon discover pathological conditions which are going on in parts and organs far out of sight. By the sense of hearing, the crepitation of a pneumonia, the friction sound of a pleurisy, the ægophony of thoracic effusions, murmurs attending defects in the mitral and semilunar valves of the heart, the bruit of an aneurism, the fly-buzz of arterio-venous aneurism, the click elicited by the contact of a sound with a calculus, and the crepitus of fracture, can all be ascertained.

Movements.—These may be less or greater than normal, or they may be constrained, or eccentric. Examples of *diminished mobility* are seen in cases of fractured ribs, or of collapsed lung—where the walls of the chest, on the injured side, become almost quiescent. An inflamed joint immediately seeks rest, and a broken arm or leg enforces a suspension of voluntary muscular

movements. *Excessive*, or *exaggerated*, or *involuntary movements* are witnessed in the walls of the chest in cases of difficult breathing, either from pulmonary or cardiac disease. There are excessive movements which attend the loss of the governing or inhibitory power of the nervous system which regulates muscular action, as is seen in chorea, paralysis agitans, nystagmus or oscillating eyes, epilepsy, hysteria, and ataxia.

Constrained movements often reveal serious structural disease. Incipient spinal caries may be detected by the mechanical, cautious, and shuffling walk of the child, before any external deformity can be noticed. *Eccentric movements* are seen in cases of infantile paralysis, in which the loss of power in the extensors of the thigh compels the child to advance the limb by the action of the muscles placed on the outer aspect of the pelvis, in doing which the extremity is swung around in the segment of a circle, instead of being carried directly forward.

SMELL.—The sense of olfaction is as quick to appreciate odors of an unpleasant as of a pleasant nature. In this way dissolution of the tissues, necrosis of bone, stercoraceous fistula, nasal catarrh, or incontinence of urine can be detected. The odor of hay, which often attends pyæmia, can frequently be so distinctly recognized, as to cause suspicion of the existence of this disease, before anything is known about the history of the case. There is, also, a peculiar, earthy smell, which belongs to the soft parts when undergoing mortification, and which is detectable by the olfactories, in many instances, in advance of the exposure of the diseased tissues. As a final illustration under this head, I may mention the offensive odor discoverable on inhaling the breath of a patient laboring under obstruction of the follicles of the tonsils, an odor which results from the decomposition of the retained secretion.

INTERROGATION OF THE INTERNAL ORGANS.

In order to make a diagnosis thorough, the condition of the internal organs must be ascertained. This will include an examination of the organs of circulation, respiration, and digestion, as well as of those of the genito-urinary apparatus and the nervous system.

CIRCULATION.—Under this head, the attention of the practitioner will be directed to the state of the heart and of the bloodvessels, noting the strength, regularity of beat, and sounds of the former, all of which exercise no small influence in enabling the surgeon to decide as to the propriety of severe and tedious operations, and especially as to the administration of anæsthetics. When the inquiry extends to the bloodvessels, the relation of atheroma to aneurism, and to senile gangrene, must be considered, as must also the presence of a varicose condition of the surface veins of the chest and abdomen, indicative of obstruction in the deep-seated venous trunks of those cavities; the pulsation of the jugular veins in anæmia; and the relation between phlebitis and embolism, and between varicose veins of the lower extremities and leg ulcers. In like manner, lividity of the surface is important, as revealing defective aeration of the blood from obstructive causes or from cardiac disease.

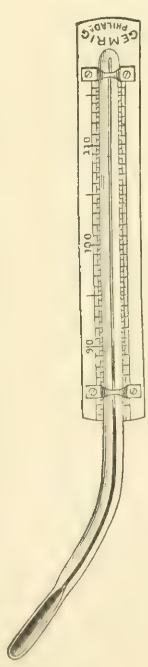
The state of the circulation is usually determined by the pulse, and while the fingers rest on the artery, there should be observed the force of its beat, its regularity, its volume, and its compressibility. The influence of emotional causes, of age, and of sex, on the frequency of the pulse, must be noted. In the case of a person laboring under temporary excitement, or in that of a nervous woman, agitated perhaps by the visit of the surgeon, the pulse will

often vary as many as twenty or thirty beats in as many minutes. Even persons in health present variations in the rapidity of the circulation at different times; and in women and children, the pulse is always more rapid than in men or in persons advanced in life. In view of the above peculiarities, the medical attendant who is familiar with the details of his profession, generally asks some preliminary or general questions, in order to place his patient at ease before proceeding formally to examine the state of the circulation. As a rule, in all inflammations seated below the diaphragm—for example in peritonitis and enteritis—the pulse is hard, contracted, and cord-like; whilst in those which are supra-diaphragmatic, it is full and bounding. In compression of the brain, the beat of the artery is slow, full, and labored, while in concussion, it is frequent, small, and feeble. In both of these conditions, a gradually increasing rapidity of the pulse presages a fatal termination. Gastric disturbance through reflex agency, and cardiac disease from mechanical disability, will often give rise to an irregular, an intermittent, or a dicrotic pulse. Profuse hemorrhage imparts to the arteries a peculiar, gaseous feel, with a tremulous and jerking movement. In grave injuries of the extremities, the absence of pulsation in the principal vessels of the part determines the question of amputation.

Thermometry.—The relation which subsists between circulation, tissue metamorphosis, and the resulting evolution of heat, has rendered the use of the thermometer a valuable adjuvant both in diagnosis and prognosis. The normal temperature of the body lies somewhere between 98° and 99° Fahrenheit. Before 1636, Sanctorius had drawn the attention of the profession to the importance of thermometrical observations as an index of morbid changes in the system; yet the first experiments, made to ascertain the local temperature of an inflamed part, were those of John Hunter in a case of hydrocele. The instrument used, however, was the ordinary thermometer, and was consequently badly adapted for obtaining accurate results. Two forms of clinical thermometer, of which the first is the best, are illustrated in Figs. 23 and 24. Another excellent form is shown in Fig. 96, page 527. When used, the instrument should be placed either under the tongue or in the axilla. If in the latter region, the thermometer should be retained in position by placing the arm close to the side, and should be allowed to remain about ten minutes, when the mercury will have risen to the highest point it is likely to reach. It is customary to take two observations each day; one about eight o'clock in the morning and the other at seven o'clock in the evening. These should be recorded upon a temperature sheet kept for the occasion, and placed either at the head of the bed or in some convenient place for reference.

Fig. 23.

Fig. 24.



Clinical thermometers.

Between the elevation of temperature and the frequency of the pulse, there is some general correspondence; that is to say, for every degree of heat above 98° Fahr., there are about ten pulsations of the heart more than when that organ is beating with its normal frequency. Every degree

above the normal temperature, is an evidence of increased tissue metamorphosis, and when the thermometer records 105° or 106° Fahr., the danger to life becomes imminent. In fatal cases of disease or injury, the temperature rapidly falls on the approach of death; an occasional exception to this is sometimes witnessed, however, in instances of fatal injury of the head or spinal column.

Respiration.—The function of respiration may be disturbed from mechanical, from pathological, or from emotional causes, and the phenomena to be observed are the frequency, the ease, and the regularity with which the process of breathing is executed. Mechanical interruption of respiration may be caused by a tumor pressing on the trachea, by the presence of membranous formations in the larynx or windpipe, by tumors in the vicinity of the rima glottidis, or by foreign bodies within the œsophagus. In like manner hydrothorax, empyema, and pneumothorax, by pressing the lung back towards the spine, will give rise to difficult and labored breathing. In pneumonia, the inflammatory infiltration which floods the parenchyma of the pulmonary tissue, not only presses the air out of the air-cells, but also prevents their expansion. This necessitates abnormally frequent respiratory acts, the lung attempting in this way to compensate for the deficient aeration, incident to imperfect expansion. Tubercular infiltration produces similar phenomena. Cardiac disease will also induce hurried breathing, especially when the patient is compelled to walk, to climb an ascent, or, sometimes, even to change his position, the muscular efforts acting as a stimulus to the organ. The respiration may be slowed or quickened by disease of the medulla oblongata. The latter frequently suffers in cases where, in consequence of organic changes in the kidneys, these organs are unable to eliminate the redundant products of tissue waste, when their retention in the system soon begins to exert its toxic effects on the brain and other organs of the body. Blood thus loaded with metamorphosed tissue becomes an anæsthetic to the nerve-centres, producing stupor, with labored breathing, which may alternate with excitement and rapid respiration when the organs begin to feel an urgent need for better blood. The sluggish flow of the blood through vessels which have undergone atheromatous degeneration, will also explain similar phenomena so often witnessed in persons thus affected. In many instances, the two acts of respiration, inspiration and expiration, are not equally involved; thus in croup, in œdema of the larynx, and in certain cases of laryngeal tumor, the inspiration is most embarrassed.

There is a singular power of compensation resident in the human body, which under extraordinary conditions is exhibited in a very striking manner: thus when a rib is broken, in order that the process of repair may not be disturbed, the movements of the corresponding side of the chest are greatly diminished, while the deficiency is measurably supplemented by the diaphragm and the muscles of the abdomen. In pleuritis, the inspiration is brought to a sudden check before the full expansion of the thoracic walls has been completed.

There are significant *sounds* accompanying the respiration, which possess great diagnostic value. For example, the tremulous voice, which accompanies extreme weakness; the hiccough, so often connected with grave disorders, or following upon the appearance of mortification; the grunting respiration which attends caries of the vertebræ; the stridulous sounds caused by the air passing between obstructions in the respiratory tube; the obscure, mumbling articulation of words in cases of inflammatory swelling in the faucial and pharyngeal parts; the whisper or aphonia from swelling of the larynx or paralysis of the vocal cords; and the tracheal râles which announce the near

approach of death. Emotional disturbances of respiration are characterized by full inspirations and expirations, following each other sometimes rapidly, then more slowly, and often executed in a jerking or tremulous manner. There must also be mentioned the slow, stertorous and puffing respiration from paralysis of the faucial and buccinator muscles, the result of cerebral compression.

The respiratory *movements* of the thorax are often observed with a view to furnish the rational signs of disease. In pleuritis, any attempt at taking a full breath is not only followed by acute pain in the side, but the inspiratory act itself is suddenly arrested by the suffering induced. The same test will, in fracture of the ribs, develop crepitus, which may be either felt with the hand or heard with the ear, applied over the injured region. In swellings suspected to be herniæ, the diagnosis is strengthened by noticing, in the tumor, a distinct impulse on coughing.

NERVOUS SYSTEM.—Much valuable information may be gleaned by testing the *common sensibility* of the skin, mucous membranes, and muscles. For the coarser examination of the cutaneous sensibility, an ordinary pin, or a pair of compasses will answer; but, for nicer and more accurate results, the æsthesiometer, of which two forms are shown in the annexed cuts (Figs. 25 and 26), should be employed.

Fig 25.

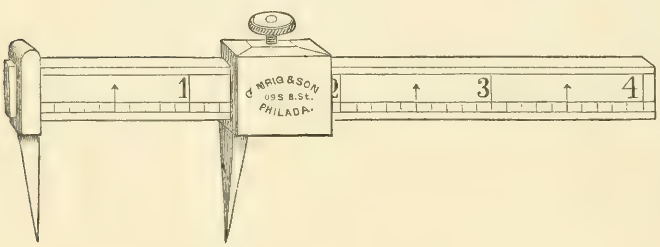
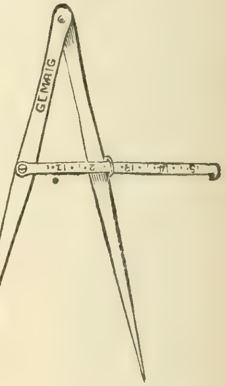


Fig. 26.



Æsthesiometers.

This instrument has a length of four inches, divided into tenths. The acuteness of the sensibility is determined by the greater or less nearness at which the touch of the two points can be recognized as separate impressions.

The presence of certain morbid poisons circulating in the blood, among which may be instanced that of syphilis, will lessen very much the acuteness of sensibility of the skin, and the same is true of a number of nerve-lesions which are followed by numbness. The sensibility may be excessively exalted (*hyperæsthesia*), so much so, indeed, that the gentlest touch with a feather or the finger will be intolerable, and will give rise to signs of extraordinary suffering. Hyperæsthesia is among the common phenomena of hysterical joints and of mimicked disease of the spine. The qualities of sensibility, or its perversions, are seen under different phases; sometimes as *burning*, an evidence of nerve-injury; sometimes as *itching*, as in poisoned wounds; sometimes described as a feeling like that of ants crawling over the surface (*formication*); or of nettles being brought in contact with the skin (*urtication*); or of a current of *air* passing over the affected part. Such conditions of the peripheral

nerves may be due to reflex impressions, or to organic changes in the spinal cord, or other ganglionic masses of neurine.

The absence of certain *reflex movements*, as those proceeding from tapping the patellar tendon, the tendo Achillis, or the cremaster muscle over the spermatic cord, are supposed by some writers to indicate serious changes in the structure of the spinal marrow, though there are other authorities who attach little importance to such tests.

Significance of Pain.—It is frequently found to be the case that parts which in their normal state exhibit little sensibility, become exquisitely sensitive when inflamed. The entire muscular system of a child is frequently thrown into violent paroxysms from an inflamed gum, which, in the healthy condition, is quite insensible. Inflammation of the hard, callous tissue of the heel, so admirably constructed to endure pressure, occasions intolerable suffering. Pain, of which we are only conscious through certain impressions transmitted along special tracts of the medulla spinalis to the brain, thus possesses diagnostic value. Pains differ in quality, location, and duration.

(1) *Quality of Pain.*—Shooting, darting, or shuttle-like pains belong to carcinoma; burning pains to injury of the nerves and inflammation of the skin; itching pains to poisoned wounds; dull, heavy pains to rheumatism; gnawing or boring pains to disease of the bones; throbbing pains to inflammatory transudations occurring in and beneath dense or unyielding structures, as in whitlow and palmar abscess; and sickening pains to contusions of the testes.

(2) *Location of Pain.*—Disease is not always situated at the point where pain is experienced. Pain is very commonly felt at the knee, in coxalgia; at the extremity of the urethra, in vesical calculus; along the ureters or down the thighs, in renal calculus; and at the inferior angle of the scapula, in inflammatory disorders of the liver. Disease at the root of the fifth pair of nerves will excite pain in the jaw and face. Many serious errors have been committed in locating disease by the misleading influence of local pain.

(3) *Duration or Constancy of Pain.*—Constant pain is usually inflammatory in its origin; intermittent pain, neuralgic. In peritonitis, the extreme sensibility or pain continues without abatement; in colic, it is paroxysmal; the pain of peritonitis is aggravated by pressure, while that of colic is relieved by the same means. Fixed pain, that which never shifts its position and is continuous for a long time, even though not severe, should never be treated as a light matter. Fugitive pains are usually rheumatic or neuralgic. The sudden cessation of pain in an inflamed part often announces the commencement of gangrene.

The importance to be attached to pain must be regulated in some degree by the temperament of the individual suffering it. There are persons whose nervous system and whose mental and emotional natures are so constructed, that the slightest pain is followed by extravagant or exaggerated manifestations of suffering; while there are others, heavy and phlegmatic in their organization, or possessing an iron will, who either do not feel pain as much as others, or who endure it with singular fortitude and stolidity.

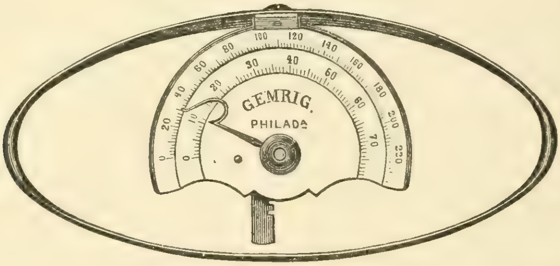
Motility.—Many obscure morbid conditions are unravelled by studying the behavior of the muscles. There are three sources from which eccentric phenomena of the muscular system may be derived: (1) the cerebro-spinal centre; (2) the nerves which supply the muscular fasciculi; and (3) the sarcous cells. Among the most common morbid disturbances of muscles are loss of power, tremors, spasms, twitchings, contractions, choreic movements, and wasting or atrophy.

Loss of power may affect one muscle or a number of muscles; one or both

extremities; the half or the whole of the body. When half of the body is affected, the cause is usually referable to the brain. When a single extremity or both lower extremities are paralyzed, the cause is to be sought for in the spinal marrow. A single muscle or group of muscles may be paralyzed from mechanical causes, such as the pressure of a morbid growth, or of a mass of exuberant callus. The nerve force may be suddenly exhausted by overtaxing the muscles, and this exhaustion may be followed by temporary or reflex paralysis. *Spasms* and *twitchings* of the muscles may be excited by the mechanical irritation from the spiculæ of a broken bone. Local irritations frequently provoke, through reflex agency, general spasms of the muscular system, as is witnessed in the convulsions which accompany difficult dentition, or which are brought on by a tight phimosis, by overloading of the stomach with crude ingesta, or by uterine disease. Permanent *contractions* of the muscles often occur, causing deformities of the limbs; a class of cases exceedingly unpromising, as the contractions depend upon structural changes which are altogether irremediable, namely, sclerosis of the anterior columns of the spinal cord. In fracture of the vertebræ, the particular region of the spine involved is ascertained by observing which muscles are rendered helpless.

Loss of power is also a result of fatty metamorphosis of the sarcous substance, rendering its cells incapable of being affected by nerve force. Those neuroses which arise from peripheral causes, are, of course, most amenable to treatment, as the cause is in many instances a removable one. In these affections of the nervo-muscular system, the use of the faradic and galvanic currents becomes necessary, in order to test not only the pathological alterations of the muscles, but also to ascertain where the defect lies; that is to say, whether in the centre of power, in the nerve of communication, or in degenerated fibre. An instrument called the dynamometer (Fig. 27) is employed

Fig. 27.



Dynamometer. The outer scale represents kilogrammes, and the inner myriagrammes.

to measure the degree of power. The movements of the pointer on the dial-plate, when grasped by the hand of the patient, indicate the force exerted, in kilogrammes, while the stretching of the spring in the longitudinal direction, by an arrangement of cords and rings, indicates the force of the lumbar muscles, or the lifting power, in myriagrammes.

Digestive Apparatus.—The wide range of sympathies possessed by the digestive organs confers upon them a notable distinction in the production of morbid phenomena. This fact is no matter of surprise to the anatomist, who is familiar with the rich supply of nerves derived from the sympathetic, and their intimate communication with those of the cerebro-spinal system. Many disorders of the circulatory, respiratory, nervous, and genito-urinary organs, though but reflected irritations from some portion of the intestinal tract,

would, if their origin was not understood, assume the gravest significance in the mind of the practitioner. In studying the bearings of this division of the subject, the inquiry should commence at the mouth, and pass downward to the termination of the intestinal tube, including the different glandular organs contained in the abdominal cavity.

In the tumid, fissured and pale *lip*, are to be seen the indications of struma, and of anæmia; in the soft, spongy and bleeding *gum*, a scorbutic state of the blood, or the constitutional effects of mercury or of phosphorus. The inflamed and swollen gum satisfactorily explains the fretfulness, otalgia, startings and convulsions of the infant. The constitutional effects of silver, of lead, and not unfrequently of tubercular disease, are shown in characteristic lines upon the gums.

Among the multiform manifestations of syphilis are the notched incisor *teeth* of the permanent set. The failure of a tooth to appear in the dental arch, if associated with enlargement of the jaw, suggests the probability of a dental cyst; while an inflammatory swelling and abscess of the face and neck, about the angle of the jaw in the adult, will direct the attention of the surgeon to the possible eruption of a wisdom tooth.

The *tongue* constitutes an important index of both general and local disorder. The *dry* tongue is a common attendant of febrile excitement, and is the result of arrested secretion. A similar appearance of the organ is seen in persons who sleep with the mouth open, and is due to evaporation of the natural moisture of the part. Habitual dryness of the tongue from this cause should lead the practitioner to examine the nasal cavities for polypi or other morbid growths. A dry tongue with rigidly prominent papillæ, occurring in the course of traumatic and other fevers, is always a source of anxiety to the watchful physician. The dry, red, and glazed tongue is among the common signs of gastro-intestinal inflammation, as is a similar condition of the fauces and pharynx. In anæmia the organ is pale, flabby, and soft. The *coating* which encrusts the tongue when it is furred, is made up of epithelial cells, the *débris* of the various secretions of the mouth, altered blood-corpuscles, etc. A thin white coat is an evidence of debility, and demands tonics. A heavy white coat, tinged with yellow, implies derangement of the biliary function. A dark, pasty crust, adhering in strips, and found also attached to the gums, constituting sordes, reveals blood disorganization, and is the attendant of low forms of fever. It should not be forgotten that a catarrh of the throat will often cause a coated tongue, when the alimentary tract in all other portions is not implicated. The *form* of the tongue is not without diagnostic significance. In intra-cranial inflammations, when the brain is not subjected to too much pressure from transudations, the organ will be narrow and pointed; in chronic derangements of the digestive organs, it will become broad, fissured, and rounded at the borders; and in inflammations of the respiratory organs, it not infrequently is seen to be transversely concave, from depression of its centre and corresponding elevation of its sides. The *motions* of the tongue are well worthy of observation. A tremulous state of the organ, or difficulty in its protrusion, frequently witnessed in low fevers, betokens great danger. When thrust out to one side, there is probably a brain-lesion on the opposite side. *Angeiomatous growths* appear occasionally on the tongue, and cause, in the affected part, a blue, spongy enlargement. *Mucous patches* on the tongue disclose constitutional syphilis.

The *sublingual space*, where the openings of the sublingual and submaxillary salivary ducts exist, should not escape inspection. Tumors occurring in this region are likely to be either ranulæ or salivary calculi.

Difficult deglutition, imperfect or guttural enunciation, cough, and stiffness of the neck, will demand a critical examination of the *fauces* and *pha-*

rynx—observing if there exist any elongation of the uvula, any hypertrophy of the tonsils, any enlargement of the pharyngeal glands, any post-palatine purulent secretion, or any swelling in front of the cervical vertebræ, the location of post-pharyngeal abscess from diseased bone. Inability to swallow solids, with return of the alimentary bolus, demands exploration of the *œsophagus* with appropriate bougies for the detection of stricture.

Vomiting, when there has been a history of chronic dyspepsia, accompanied by loss of flesh, will suggest a careful examination of the abdomen for internal carcinoma. Sudden attacks of vomiting, with pain and flatulence, attract the attention of the surgeon to the hernial passages. The appearance and the odor of the ejected matters must not escape observation, stercoraceous emesis always denoting intestinal obstruction from some cause.

In determining the outline of the *solid organs* within the abdomen, and thus detecting alterations in their *size*, the surgeon resorts to manipulation and percussion. In the same way the *form* of the organ can be ascertained, as in displacement of the kidney, distension of the gall bladder or of the urinary bladder, and fibroma of the uterus. Accumulations of fluid within the abdomen, either cystic or peritoneal, are to be recognized by palpation, by use of the grooved needle, or by employment of the aspirating trocar. The differentiation of fluids taken from the abdomen, and their relation to special diseases, will be materially aided by observing their physical, chemical, and microscopical characteristics. The thin and light straw-colored liquids are generally *peritoneal* (*ascites*); the dark, thick, ropy, and gelatinous, *ovarian*; and the clear, limpid, and spontaneously coagulating, fluids from the *broad ligament*. A characteristic cell is also said by Drysdale to be found in ovarian fluids.

The *alvine discharges* require to be scrutinized. Putty-colored dejections point to hepatic disorders, and are often found associated with an icteroid discoloration of the conjunctiva and the skin. The admixture of *blood* with the discharges will suggest ocular, instrumental, or digital exploration of the anus and rectum; since blood, and often mucus, may proceed from fissure, from hemorrhoids, from stricture, from carcinoma, or from syphilitic disease. The *form* of the feces may also reveal the existence of stricture, being in such cases small, flattened, angular, or round like pipe-stems. The character of *pain* (if present), and the period at which it is developed, will also aid in forming a diagnosis in cases of anal and rectal disease. For example, there is pain in defecation, both in hemorrhoids and in fissure; but in the former it is experienced chiefly at the time of evacuating the bowels, soon passing over and leaving only a sense of warmth for some time after, while in fissure the pain comes on at variable periods after defecation, and increases in severity for several successive hours. *Tenesmus* is a common symptom of colitis, but may be equally urgent as the result of a foreign body being lodged in the lower extremity of the bowel. When tenesmus is accompanied by frequent and small watery passages, it is often significant of rectal impaction.

Genito-urinary System.—The *sexual systems* of the two sexes play a very important part in the causation of both functional and organic disorders of the human body. Impotency, the loss of the venereal appetite, and unnatural excitement, in the male, are conditions which demand for their proper understanding a critical inquiry into the state of the brain and spinal marrow, the constitution of the urine, the condition of the organs themselves, and the habits of the patient. The connection between priapism and spinal or cerebro-spinal injuries; between spermatorrhœa and nervous restlessness, with palpitation, dyspepsia, and loss of strength and spirits, will not escape the notice of the careful observer. Retraction of the testicle, and pain along

the course of the ureter, in renal colic; pain at the meatus after urination, and elongation of the prepuce, in vesical calculus; phimosis and its relation to urinary incontinence, convulsions, and eczema; a diminished and twisted stream of water in stricture; urethral discharges and their connection with stricture; and frequent micturition as an indication of enlarged prostate and of cystitis, are all subjects which will demand investigation.

The influence of sound *kidneys* on the success of operations is such that no prudent surgeon would willingly undertake an operation without previous examination of the urine, unless in cases where operative measures were unavoidable. Examination of the urine should include an investigation of its quantity, specific gravity, color, reaction, and composition; while the means for determining these points are measurement, the use of the urinometer, ocular inspection, the employment of chemical reagents, and examination with the microscope. The principal substances to be sought for are albumen, blood, pus, muco-pus, sugar, urates, phosphates, and oxalates; and the presence or absence of each of these has an important bearing on both diagnosis and prognosis.

SHOCK.

BY

C. W. MANSELL-MOULLIN, M.A., M.D. Oxon., F.R.C.S.,

FELLOW OF PEMBROKE COLLEGE, OXFORD; LATE RADCLIFFE'S TRAVELLING FELLOW, UNIV. OXON.; SURGICAL REGISTRAR TO THE LONDON HOSPITAL, LONDON.

Originally employed in any case of sudden death or collapse following injury or mental emotion without discoverable lesion, the term Shock has, step by step with the increase in knowledge of physiology and the extension of experimental inquiry, become more and more definitely associated with the conception of a sudden check to the circulation brought about through the agency of the nervous system, and resulting either in a death so immediate as scarcely to have a parallel, or in a condition of prolonged prostration with or without a more or less successful reaction. Such a result can only take place through the direct influence of the nervous system. Long ago, Travers[1] pointed out that frequent instances of sudden death, consequent upon injuries which left no trace of their destructive operation upon the texture of the vital organs, and that other instances of death after the lapse of a few hours or days, and some even of weeks, from the injury, admitted of no other explanation according in any degree with the history and symptoms of the malady, than a suspension or failure of the nervous power. Nor is it less clearly proved by the spontaneous disappearance of all symptoms in cases of recovery, sometimes almost as rapid as their onset (for patients left pulseless and apparently moribund, without external injury, may be found on the succeeding day restored to the tone and tranquillity, comparatively speaking, of health), that there can be associated with it no serious structural lesion. Of course it must not be inferred that no change at all has taken place, but simply that it is not within range of perception by means of our present methods of investigation; and, indeed, it is to be expected that, with increasing knoweledge of the conditions under which the manifestation of that form of molecular motion known as nerve-force is possible, we shall some day be able to form an idea of the way in which its action may be modified or suspended, without the production of any visible alteration of structure.

Causes of Shock.

Whatever may be the immediate cause of shock, whether it result from a purely mental source or from a serious bodily hurt (for probably either alone is sufficient, although in general each bears a share), everything denotes diminished energy of circulation: the pallor and coldness of the skin, the weakness and small volume of the pulse, the difficulty of respiration, the languor

[1] Treatise on Constitutional Irritation, p. 431.

and general depression, all point to some failure among those forces that maintain the circulating fluid at the necessary tension; to some difficulty affecting the motive impulse of the heart, or the peripheral resistance of the capillaries, or the state of tone of the smaller vessels, arteries as well as veins; for these are the forces mainly concerned in keeping up the arterial pressure on which the circulation depends. That the first of these three, the heart, is affected, can have escaped the notice of none who have ever experienced emotion of any kind; with regard to the others, there would be greater doubt if it had not been proved by experimental demonstration; though it might reasonably have been surmised from the well-known occurrence of syncope, in failure of the heart's power from organic disease or other causes, that for the production of shock, unattended by loss of consciousness, some additional element must be present. With regard to the causes of shock, there can be no doubt that *mental emotion*, especially joy or fear, of itself, without bodily hurt of any kind, may be followed by the gravest form of shock, resulting in immediate death even where there is no probability of organic disease of the heart.

Many years ago, the janitor of a college had rendered himself in some way obnoxious to the students, and they determined to punish him. They accordingly prepared a block and axe, which they conveyed to a lonely place, and, having dressed themselves in black, some of them prepared to act as judges, and sent others of their company to bring him before them. When he saw the preparations that had been made, he at first affected to treat the whole thing as a joke, but was solemnly assured by the students that they meant it in real earnest. He was told to prepare for immediate death, for they were going to behead him then and there. The trembling janitor looked all around in the vain hope of seeing some indication that nothing was really meant, but stern looks everywhere met him, and one of the students proceeded to blindfold him. The poor man was made to kneel before the block, the executioner's axe was raised, but, instead of the sharp edge, a wet towel was brought smartly down on the back of the culprit's neck. This was all that the students meant to do, and, thinking that they had frightened the janitor sufficiently, they undid the bandage which covered his eyes. To their astonishment and horror, they found that he was dead.[1]

And although this extreme effect may not be common, instances of catalepsy, hysteria, idiocy, and other morbid mental conditions are in plenty: nor can this be in any way a matter for astonishment, when the effects of mental impressions on the functions of the body are taken into consideration. A familiar instance of their influence is seen in women during lactation: the qualities of the milk are from this cause often suddenly changed so as to produce very serious effects upon the infant: in some recorded cases the result has proved fatal. It is remarkable and characteristic that severe shocks to the system from mental emotion, after the more immediate effects have passed away, often leave some organ permanently impaired in its function. Sudden fright, for instance, has produced deafness.[2]

There is, however, in individuals the greatest possible difference in this respect. No two persons are ever affected in the same way by mental emotion, or to the same degree: some are but slightly moved by that which influences others in a most serious manner; others again are greatly disturbed by slight accidents of some special kind, while they are altogether heedless about troubles much more grave; and under different circumstances, at different times of life—nay, even at different times of the day—the same people may remain apparently unconcerned, or be quite overcome. Yet sometimes, when the temperament and nervous susceptibility of a patient are well known, a prediction may be hazarded as to the probable effect of an injury or opera-

[1] Lauder Brunton, Shock and Syncope.
[2] Savory, Collapse; Holmes's System of Surgery.

tion, and timely help be thus gained in the question of prognosis. *Sex* is not without its influence, though it is scarcely possible to estimate how far susceptibility to shock is due to difference in habits of life and physical development, and how far to a quicker sympathy and more ready emotion. The effects of *age* on the production and course of shock are more certain, especially if account be taken of the complete absence of anxiety in the young, and of the apathy so common in the old. It is generally said that the immediate results of an injury are worse at these two periods of life than at any other; but, in the case of the young, much allowance must be made for the relative amount of damage sustained, for the very serious effect of even, comparatively speaking, a slight loss of blood, and for the great susceptibility to cold. In the aged, shock is more particularly characterized by uncertainty, both as to its course and persistence; not unfrequently its intensity is diminished and its duration prolonged; and often, when all seems going on well, the heart's strength fails suddenly, and the patient dies when least expected. It must be mentioned, however, that Nussbaum and others will not admit cases of this kind as examples of death from shock, believing that hemorrhage, by means of the effects that may follow it even after some time has elapsed, is much more likely to have been the cause of the fatal issue.

Pain, when intense and unintermitting, has been known to prove fatal, but probably in the majority of cases by inducing syncope, though it has a distinct effect upon the heart's action; patients, while in a state of shock, whether arising from bodily or mental origin, seldom feel any but the most acute agony; and in many of the examples brought forward, protracted labors for instance, extreme muscular exhaustion has been of material help in causing death. It is more singular that, as Astley Cooper pointed out, the moment of transition from intense agony to perfect ease has been known to prove fatal.

Deep *mental pre-occupation*, generally met with under the form of extreme excitement, undoubtedly possesses the peculiar power of postponing the occurrence of shock, perhaps in the same way that the will, or the violent irritation of a sensory nerve, can for a time suspend perception. It is especially in military surgery that cases of this kind are recorded—where serious and painful wounds are not even known of, till long after their infliction. It is only the onset of the shock, however, that is delayed: its intensity loses nothing from the combined effect of the injury, pain, commencing fever, exhaustion, fear, and perhaps even despair. Another mental condition that may be mentioned as having a peculiar influence is that of intense and perhaps delayed *expectation;* at least it would seem that this might assist in the explanation of those deaths, the most mysterious of all, which follow immediately on some trivial operation, while accidents seem to be without effect; perhaps there may be a comparison between these cases and those already mentioned of sudden death on the cessation of pain; in each it seems to follow the breaking off of a condition of extreme mental tension.

Cases attended by Shock.

The majority of the cases of shock met with in surgical practice, follow accidents or operations, serious either from the actual extent of the injury inflicted, or from the fact that special organs or textures have been involved. *Burns and scalds*, especially when the area involved is extensive, even if the depth is insignificant, are among the most common causes of shock; then come *contused and lacerated wounds*, such as are produced by the violent crushing of a limb, and *capital operations*, though by care and attention in the case of

these, the severity of the resulting shock may be much reduced. In all, the danger is great in proportion to the proximity of the injury to the trunk, a fact that is conclusively shown by the results of amputations on the lower limbs; and it would seem as if the injury to the bone itself had some special influence, for Pirogoff[1] saw two men die on the table during amputation through the thigh (one for injury, the other for chronic disease of the knee-joint), at the instant that the bone was being sawn through; a spasmodic contraction passed over the muscles of the body, the face became pale, the eyes lost their lustre, the pupils dilated, and death followed at once—in neither case was an anæsthetic administered. Furneaux Jordan[2] too, watching a thermometer placed in the axilla, while an amputation was being performed, observed on several occasions a drop of as much as one-fifth of a degree during the application of the saw. There is a special gravity attached to those cases of shock which result from *railway accidents*, probably in no small measure owing to the part taken in their production by mental causes, and to the general concussion sustained by the body in its suddenly suspended motion; for instances of severe and lasting shock, often assuming most insidious forms, are met with from time to time in occurrences of this kind, without there being any definite or marked bodily lesion, and, indeed, are often the more severe when this is quite absent, and there is no other explanation than a general or mental cause.

Simple concussion of the brain would present a frequent and good example of shock, if it were possible to eliminate and set aside the symptoms that depend upon the injury inflicted on the brain-substance itself, probably present in all, even the slightest cases, and productive of indirect as well as of direct results, if any reliance is to be placed on experimentation.[3]

As accidents involving the extremities are followed by shock, other things being equal, in proportion to their proximity to the trunk, so it might reasonably be supposed that injuries inflicted on the trunk itself would present cases of the greatest severity; and this is true not only of accidents that involve considerable damage to organs or textures—damage that might of itself render difficult the continuance of functions necessary to the maintenance of life,—but also of slighter injuries, blows or contusions, that in other parts of the body would scarcely be noticed, but which here are often, and sometimes unexpectedly, followed by results of the gravest character. Few can have passed through school-life without having experienced the effect of a blow on the *scrotum*, or on the *pit of the stomach:* the intense collapse and complete prostration that supervene at once, and may even terminate fatally, as cricketing annals unhappily show. Fischer[4] relates a case of death with all the symptoms of the deepest shock, following a few hours after a *testicle* had been crushed; and Erichsen mentions as a frequent occurrence in castration, the sinking of the pulse at the moment of division of the spermatic cord, even when the patient is fully under the influence of an anæsthetic. But it is not a little singular that, in spite of the generally received tradition on such matters, and of the undeniably grave symptoms which are so notoriously produced, there should not be recorded one single case in which death has followed in a healthy man immediately upon a blow on the abdomen, without injury to any of the subjacent viscera. Even the classical instance given by Sir Astley Cooper, and always quoted as an example, of the laborer who while wheeling a barrow, received a slight blow in the epigastrium and fell down dead, cannot be admitted,[5] though it is supported by such authority; for it did not occur within his own practice, and in the account left of it

[1] Kriegschirurgie, S. 89.
[2] Hastings Essay on Shock.
[3] Goltz, Pflüger's Archiv, 1876.
[4] Volkmann's Sammlung klinischer Vorträge, No. 10.
[5] Pollock, Holmes's System of Surgery.

there is nothing that is inconsistent with the idea of sudden failure of the heart's action, from the combined effects of degenerated structure and over-exertion. Death may, however, occur at a later period; a boy after being crushed by the end of a costermonger's barrow against a wall, was admitted to hospital in a state of collapse, from which he partially rallied towards evening, only to sink again gradually before twenty-four hours had elapsed; nor was there anything found after death that could account for this; only a little redness and stickiness of the peritoneum in one small spot behind, against the vertebræ, as of commencing peritonitis.

It often happens that *penetrating wounds of the abdomen*, and still more frequently that injuries or operations involving the handling of the viscera, such as ovariotomy, are followed by results of this nature, though exceptions are more frequently met with in this class of injuries perhaps than elsewhere. Death within five minutes has occurred after such a simple operation as tapping the liver for hydatid disease.

The patient, a man 49 years of age, to all appearance perfectly healthy, and temperate, presented himself on account of an enlargement of the abdomen which had been noticed some ten months. It was plainly a case of hydatid disease of the liver; and was of such inconvenience that the man wished something to be done. After some days in the ward, a fine aspirating trocar and canula were introduced without any anæsthetic, and a few drops of clear fluid evacuated; as no more followed, a canula somewhat larger, about the size of a small goose-quill, was inserted through the same opening immediately on withdrawal of the smaller one. A few drachms of blood-stained fluid came, and then all of a sudden the patient's face became pale and livid, his arms sank down by his side, and, with the exception of a few faint irregular beats, the pulse ceased. At the post-mortem examination, on the following day, the puncture was found on the convexity of the liver, and a probe was passed through it into a small cyst lying by the side of a much larger one; there was no great distension of the abdominal veins, and the only sign of visceral degeneration was a slightly granular condition of the kidneys.

Bryant[1] relates a very similar case, except that the amount of fluid removed was considerably greater, about nine ounces (though much more than this has frequently been withdrawn without damage), and that, while the inferior vena cava was considerably obstructed by the pressure of the tumor, a large branch of the portal vein had been perforated by the trocar.

Injuries to other abdominal viscera offer examples no less frequent and quite as characteristic. The strangulation of a portion of *small intestine*, whether in a hernial sac or by some band within the abdominal cavity, is attended at once by symptoms of the most complete prostration, and may of itself, if left unreduced, be sufficient to occasion death, without the production of peritonitis. Many more instances are on record of this result having followed the application of taxis, with or without the administration of chloroform, especially in the case of umbilical or ventral herniæ in corpulent subjects reduced by long-continued vomiting.

The same effects are produced by large doses of *corrosive poisons*, such as sulphuric and other mineral acids, or arsenic, the immediate effects of which are intense local pain, coldness and pallor of the surface, sighing respiration, and a weak, perhaps imperceptible pulse. Similar results follow when *perforation* takes place in the stomach or intestines, and their contents escape into the peritoneal cavity. The occurrence of shock after *parturition*, especially in the case of bearing twins, is probably partly due to nervous influence, and partly to the removal of pressure from the abdominal vessels by the loss of such a large portion of the abdominal contents, which must almost unavoidably occasion more or less relaxation of the vessels.[2]

[1] Lancet, June 8, 1878. [2] Lauder Brunton, Shock and Syncope.

Great *loss of blood*, especially if it has taken place suddenly, brings on all the symptoms of collapse, but usually accompanied by syncope; and certain poisons (as *nicotin* and *muscarin*) which act directly on that part of the nervous system that is in immediate relation with the heart and vessels, produce the most intense prostration of mental and bodily vigor through the diminution of vascular tension, and these cases are of more than ordinary interest, for in this way the practical physiologist is able at will, by methods the working of which is fairly well understood, to produce a condition not to be distinguished by any of its symptoms from that consequence of injury or mental emotion which has been so long unintelligible. Indeed, so close is the resemblance presented by cases of this kind to the collapse caused by abdominal injury, for example, that Furneaux Jordan and others have included hemorrhage and this class of poisons among the causes of shock. But it would seem altogether more reasonable to restrict the definition, by retaining the idea of indirect, perhaps reflex (whether traumatic or mental) origin, and to regard these cases in which the result is produced by some influence acting directly on the vascular tension, as a means of explaining those in which the same is brought about indirectly and reflexly as the consequence of some perhaps distant injury.

Symptoms of Shock.

Few conditions are more characteristic than that of a patient suffering from the graver effects of shock; none resemble death itself more closely. He lies perfectly quiet, giving no heed to anything that goes on around; with limbs helpless and prostrate, as they may be placed, or as the chance of the moment may dictate; conscious, yet seeing only in a mist, and hearing none but loud and repeated questions (though rare instances are met with in which the senses, especially the hearing, are acute beyond all measure); with no paralysis, yet replying with difficulty, in a syllabic, scarcely audible voice, and only executing with painful slowness some simple movements often left half finished. The expression of the face is quite changed; all the features, especially the nose, are smaller and shrivelled; the weary eyes have lost their lustre, and lie rolled upwards in deeply sunken sockets, surrounded by a dusky ring; the pupils in general are dilated, and react very slowly to the stimulus of light. The skin, and such parts of the mucous membrane as are visible, are pale, but livid too; the fingers and nails blue, and the skin on the palmar aspect hanging in loose folds. Large drops of sweat hang on the forehead and eyebrows; the whole body is cold; at times a shiver passes through all the limbs; and the loss of temperature is often so great as to make the thermometer fall two or more degrees. Common sensibility and the sense of pain are much blunted over the whole body; only some paroxysm more sharp than ordinary can rouse to any movement, while the worst of news is heard without emotion, so great is the already existing depression. The pulse is almost imperceptible, irregular, unequal, and very rapid; the arteries are small and the tension low; the ascent in a sphygmographic tracing is very short and sloping, but the apex fairly well marked; the presence of dicrotism in these cases probably depends upon the amount of hemorrhage. The respiratory movements are very irregular—abnormally deep, sighing inspirations breaking suddenly into a series of very superficial ones which are scarcely audible; sometimes, especially as the graver symptoms are passing off and reaction is beginning to set in, there is vomiting; the sphincters generally remain closed, but no rule can be laid down upon this point; retention of urine occurs perhaps more frequently than not, and sometimes, with this, there is partial suppression.

This death-like calm is, however, by no means invariable in cases of shock; indeed, in this respect they may present the greatest possible variety. There may be from the first a condition of the most extreme restlessness and excitability, that erethistic form which Travers has termed "prostration with excitement;" or this may follow on the former type as a kind of reaction.

The patient then tosses wildly and vaguely from side to side, as if frantic, complaining of a fearful oppression and want of breath; with presentiments of death, and a feeling of total annihilation; often shouting again and again the same thing, perhaps utterly meaningless; with a countenance expressive of nothing but a nameless anxiety and excruciating agony. No encouragement is of any use; the consciousness is unclouded, but seems altogether preoccupied by the frightful anguish; no question is answered; there is only the same constant moaning exclamation; no attention is paid to anything going on around; there is but one feeling, that of closely impending dissolution. The respiration and pulse present the same general character as in the torpid form of shock, but it is seldom that the pallor and coldness are so great; sometimes even the face is flushed, and burning thirst is nearly always felt; fluids are swallowed with the greatest eagerness, and vomited as soon. Often the limbs or the whole body are convulsed by a sudden rigor. Sleep is unknown, or there is at best a fitful slumber which gives no relief; more often, as night approaches, the incoherence becomes wild delirium. Exhaustion rapidly supervenes; a profuse and clammy sweat appears on the face, and spreads over the whole body; the pulse becomes fainter and feebler, and with a sudden cessation of all movement, often preceded by a slight convulsion, the expression alters, and the patient is dead.

In spite of the very great difference in the external manifestations of these two forms of shock, it is by no means improbable, just as under other circumstances coma and convulsions may occur together, and be due to the same cause, that the same pathological condition underlies them both—of course in somewhat different measure; at least, the distinction is so slight that either may succeed the other, and no prediction as yet is possible either from the constitution of the patient or the nature of the lesion, as to which may be the form which will supervene.

But even these are not the only, though they are perhaps the most striking, forms in which the intense depression of vital power that follows serious injury may manifest itself. Sometimes, and it is more particularly after railway injuries, as a result, perhaps, of the fright—perhaps of the violent concussion sustained by the whole body as it is violently projected into space, or jerked backwards and forwards with all the muscles unprepared—there is seen a form so insidious as to falsify the most guarded prognosis. After the accident, the patient, who has sustained no apparent bodily hurt (and this seems to be essential), appears perfectly calm and unaffected—often unnaturally so—congratulating himself on his escape; his color is good; pulse quiet; respiration tranquil; there seems nothing wrong. But at night there comes an inability to sleep, and a tendency to become feverish; the pulse becomes quicker and softer; the eye bright and restless; the extremities cool; and, even within the space of three or four days, persistent vomiting and exhaustion, running on to prostration and coma, may supervene. More frequently the time occupied is much longer, and there follows a condition which has been variously called, for want of a better name, hysteria, or hypochondriasis. It is true that much doubt has been justly thrown on a great number of these cases; in many, the symptoms have been simulated completely; in others, and probably the greater number, the real cause has been a slowly progressing, chronic cerebrospinal meningitis; but there still remain a few (presenting no objective signs) to which this explanation will not apply; a few in which, as the

result of an accident, and coming on too soon afterwards for inflammation to be the cause, there has followed either some defect or perversion of nutrition, or more or less complete loss of that which may be most aptly compared with what is known in physiology as inhibition—moral control. It has been said that this condition is really due to anæmia of the spinal cord;[1] it may be so, and this state presents a certain, but by no means close, analogy to a somewhat similar condition of the brain; but while it is exceedingly hard to understand how such a condition could have arisen primarily, it is still more difficult to imagine how it could persist; and it must always be recollected that it is a doctrine resting on clinical evidence only, there being no pathological fact that can be urged in its support.

It must, however, always be remembered that it is essential to the conception of shock, that the symptoms, or some of them in their lighter form, should make their appearance immediately after the accident. It cannot be doubted that many of the cases of sudden death which have hitherto been placed in the category of shock—cases in which an interval of some hours, or even days, have elapsed after the receipt of an injury or the performance of an operation without the appearance of any untoward complication—have not been due at all to shock in the strict sense of the term, regarding it as extreme vital depression caused by reflex nerve-influence. The greater number may probably be accounted for by *hemorrhage*, especially those later effects of it to which Nussbaum[2] attributes the strange results of accidents in advanced life; or by *septic collapse*, from the sudden absorption of poisonous matters by a large serous surface, such as the peritoneum; or by *fatty embolism*, which has been shown of late by Wagner and others to be strangely frequent after injuries, especially when involving bones.

The symptoms of shock do not by any means always present the gravity of the cases described above; there may be merely a temporary impairment of mental vigor, with a transient diminution of muscular energy, and a slight irregularity in the heart's action; signs which it is very hard to distinguish from those of syncope, if indeed it is possible. Travers[3] has said that a fit of syncope and the recovery from it present an epitome of the phenomena of shock.

There is, however, in syncope one characteristic feature—so characteristic as to have given it its name—which is very rarely met with in shock, perhaps never but in those cases which have a rapidly fatal termination; and this is the sudden and complete loss of consciousness always present, and due to the suspension of the function of those parts of the brain which have to do more especially with the intelligence. It is scarcely necessary to bring forward evidence at any length to prove that deficiency in the supply of blood to the brain is the pathological condition underlying the symptoms of syncope; the striking pallor of the face, coming so suddenly, would alone be almost sufficient; or any of those cases in which the heart being enfeebled, the sudden assumption of the erect posture is at once followed by loss of consciousness—even if Sir Astley Cooper, by ligaturing the carotids, and Flemming, by compressing them, had not shown beyond all question that it is the local change that is the cause. Nor is there any anatomical difficulty in the supposition of a sudden diminution in the quantity of blood entering the cranial cavity, for this is no longer regarded as closed, but as having sufficiently free communication between the ventricles and the subarachnoid spaces to enable the alteration in pressure to receive immediate compensation. In shock, on the other hand, it is rare for the loss of consciousness to be complete: the brain

[1] Erichsen, Railway Injuries.
[2] Ärztliches Intelligenz-Blatt, März 13, 1877.
[3] Op. cit., p. 467.

is still active, though quite unequal to the higher efforts of intelligence; its power is impaired, not abolished; and, as in syncope it appears to be the only part of the nervous system (as far as it is admissible to use the expression) affected, so in shock it suffers equally with all the rest; for in the one, the simplest cause that is efficient, is a diminution of the blood pressure within the cranial cavity; in the other, the only one that can offer any explanation of the symptoms, is a fall in the vascular tension, which is general, extending throughout the whole body. Even when there has been no loss of blood, the lividity and pallor of the skin; the diminution in sensibility; the sluggishness of the cerebral functions; the lessened vigor of contraction and readiness to respond to stimulus, shown by the muscles; the rapidity, smallness of volume, and compressibility of the pulse; the partial suppression of the secretions; and especially the long continuance of the symptoms, which are not capable of passing off within a few minutes, as in syncope—all point to some general check to the capillary circulation, and through this to an equally general failure in the arterial tension.

Pathology of Shock.

It is to experimental physiology alone that must be given the credit of not merely a plausible, but almost certainly the true explanation of the manner in which these changes can take place. It has shown that, while, on the one hand, the heart is so independent of other innervation than that contained within its own walls, for the orderly continuance of its action, that the whole of the great nervous centres may be gradually removed without destroying this; on the other hand, it is so directly under control that not only may irritation of a particular nerve running to it bring its movement to an instantaneous stop, but that even, as long as the connections are intact, the same result may follow reflexly from a stimulus applied to a centripetal nerve. It has shown, further, that the bloodvessels, veins as well as arteries, are under a control so closely resembling this, that it may be brought into action by the same stimulus; as, indeed, might have been presupposed from the close resemblance which the vessels present to the heart, in their first development. For whether the history of the individual or of the race be contemplated, in the one as in the other, at its first origin, the circulatory apparatus is uniform and simple in structure and relations; only with increasing size and complexity of other parts of the body, in accordance with the ordinary principles of the division of labor, does it become itself so complex that at length some divisions attain such a degree of specialization that they are usually thought of and studied as if they were independent and distinct from the rest. It is true that this similarity in nerve control does not seem at first sight so clear as it might be; for, according to general statements, the vasomotor system is not automatic and not distinct from the central nervous system, but reflex and situated in the medulla oblongata, with a prolongation, as experiment has recently shown, down the spinal cord; but that the power of independence, comparable to that possessed by the heart, is still retained, though, perhaps, dormant and subordinated, is shown by experiments in which the whole vasomotor supply of some part of the body has been cut off permanently; at first, the vessels dilate passively, and remain in this condition for some days, perhaps even weeks; but then they gradually recover their tone, and can contract and dilate just as before, but now, of course, only in response to local stimuli.

It may be, to use the language of teleology, that for the convenience of the rest of the organism the nerve centres that control the vessels, in place of

being widely scattered all over the body as they would have to be if they were placed on the walls of their own vessels (as in the case of the heart), have been gathered together into one group and placed centrally, still, however, leaving throughout the body some trace of independent control, or at least some power of developing it. Nor is this the only way in which the vasomotor centre may be compared with the cardiac ganglia, seemingly so unlike: for just as the latter may be inhibited through some special nerve, either by direct irritation or reflexly, so also may the former, except that, from its central position, no other than a reflex path can be known. And thus the broad principle may be admitted, as a general statement, that the heart and the vessels are but co-ordinate parts of one system, and may be simultaneously influenced in the same direction by a single stimulus; and that while Travers regarded shock as the result of nerve action on the heart alone, there is nothing in the physiology of the circulation that would preclude the posibility of a much more general effect on vessels and heart together.

But this is by no means all that the subject of shock owes to the recent extension of physiological inquiry: it is not enough that the action of the heart and the tone of the vessels (on which, with the resistance of the capillaries, depends the blood pressure), may be suspended by the direct or reflex irritation of certain nerves; it has been shown in the clearest manner that this result with all its consequences may follow distant, external injury; and external injury moreover of that peculiar form which is more likely than any other to cause shock—abdominal contusion. This was shown by Professor Goltz,[1] of Strasbourg, by a remarkable experiment:—

A frog was taken and suspended in a vertical position, with the legs downwards, and the heart exposed. After waiting a short time, till the beats were fairly regular and sent the usual amount of blood into the aorta, the frog's intestines (or the surface of the abdomen) were struck with some violence, and the result on the action of the heart and on its blood-supply noted. It was found at once that the heart had stopped; the irritation had been carried up to the medulla oblongata, and reflected thence down the vagus. After a little while, the heart seemed to recover and began to pulsate again. But there was a very remarkable difference between its appearance now and its appearance before the blow had been given. Instead of becoming filled with blood during each diastole, and assuming a deep red color in consequence, it remained quite pale and empty, and, although it contracted vigorously, the circulation remained stopped, for the heart had no blood to propel. The cause of this was not far to seek: the frog was hanging with its legs downwards, and the upper part of the vena cava was empty; the veins of the intestines, generally kept in a state of semi-contraction by the vasomotor nerves, had become relaxed, and the blood which would have filled them completely up to the heart was not sufficient, so that they were only half full. Not only had the inhibitory nerves of the heart been called into activity, but that also which regulates in a similar manner the vasomotor centre; for this result did not follow when the animal was fully under the influence of an anæsthetic, or when the vagi or splanchnics had been interrupted. In the frog, recovery followed as soon as it had been placed in a horizontal position, so that the blood could reach the heart again; in man, the stoppage of the heart in diastole would be instantaneously fatal; its weakened action, and the dilatation of the abdominal vessels, allowing the accumulation of such an amount of blood—all really as much withdrawn for the time from the general circulation as if there had been actual hemorrhage—would lower the general arterial pressure, and cause the symptoms of shock.

There can be no doubt that experiments such as these, which do not vary in the hands of physiologists, have thrown a flood of light upon much that before was mere conjecture. The suggestions of Travers and others, that

[1] Virchow's Archiv, xxvi. und xxix.

such phenomena as are presented in shock can only be produced by the suspension of the nervous power manifesting itself through the circulation, have found their clearest proof in the facts of physiology; and it may be taken as demonstrated beyond dispute, that in shock there is a reflex paralysis of the heart and the abdominal vessels. There are facts, however, which show that its action cannot be limited to these alone, but must, as might be expected from what has been said above, be extended over the whole vascular system, if not even, as Brown-Séquard has suggested, over the relation that exists normally between the blood in the capillaries and the tissues around them. For the symptoms of shock are not identical with those of hemorrhage, as under these circumstances they probably would be; and, although dilatation of the abdominal vessels leading to passive congestion has been noticed (as, for example, occasionally during ovariotomy), it does not reach, if we may trust post-mortem records of fatal cases, that extreme degree necessary to account for the symptoms. Further, Tappeiner[1] has shown, by ligaturing the portal vein and then estimating the amount of blood contained in its radicles, that even in mammals, such as rabbits, with relatively large abdominal viscera, contrarily to the generally received opinion, all the vessels of the abdomen, veins and arteries together, are not of sufficient capacity to hold more than sixteen per cent. of the total amount of blood in the animal's body—a quantity, as long as the other bloodvessels preserve their innervation intact, quite unable to cause such a loss of pressure; for Müller[2] demonstrated that, as long as the vasomotor nerves retained their power, the total amount of circulating blood might be halved or doubled without producing any appreciable difference. The same result is arrived at after section of the splanchnic nerves on both sides: by doing this, all the vessels of the abdominal viscera are completely cut off from their vasomotor nerves, and distended to the utmost by the blood stagnating in them (for it does not seem likely that active dilatation can ever take place; the nerve-supply is doubtful, and the muscular mechanism in the walls unknown); yet by actual measurement, with a manometer, of the arterial tension after this has been done, it is found that the fall is never equal to, and in the majority of cases not half as great as, that which must occur in a case of hemorrhage if the symptoms are comparable in their severity to those of an ordinary case of shock.[3] Indeed, so far is the general arterial tension from falling below the point consistent with the maintenance of life, that animals in which this has been done on both sides simultaneously, have been known to make a thoroughly good recovery—the local centres assuming the function which the medulla and spinal cord are no longer able to carry out, and the vessels gradually resuming their calibre and regular tone.[4]

From these experiments it is legitimate to infer that something further is necessary; and Fischer is probably correct in stating that in shock there is paralysis of the whole vasomotor system, that of the splanchnics being, on account of their peculiar distribution, the most marked. As the vessels have been shown to be all under the control of the same nerve-centre, it must be admitted that there is nothing improbable in this; and it certainly affords a reasonable explanation (through the stagnation of venous blood in the capillaries) of the lividity of the skin and all the visible parts, so different from the waxy pallor of hemorrhage. There are a few facts that point to the possibility in some cases of different parts of the vascular system being affected in different degrees. Goltz, in his experiments, sometimes found that the heart was very much more interfered with than the vessels; some-

[1] Tappeiner, Ludwig's Arbeiten, Leipzig, 1872.
[2] Müller, Ludwig's Arbeiten, 1874.
[3] Tappeiner, loc. cit.
[4] Asp, Ludwig's Arbeiten, 1867.

times, with conditions apparently similar, the reverse; and, perhaps, something of this kind may be suggested as an explanation of the extreme congestion of the portion of intestine above a strangulation, as compared with the condition of that below.

It is to be feared that this theory, which has been adopted in its entirety by Fischer, and which must be regarded as an enormous advance upon all previous views, cannot yet be admitted as thoroughly sufficient. It cannot but be considered as most strange that injuries to the cervical spinal cord are not invariably followed by instant death; for while the heart suffers under the general shock, there is absolute paralysis of every vasomotor nerve in the body, head and upper extremities included; yet, though the shock is sometimes undeniably severe, it is certainly not in the majority of fatal cases the cause of death; and there are several instances on record of continuance of life with complete paralysis of motion and sensation in all parts below the seat of injury, the normal arterial tension being restored and maintained as usual by means of the peripheral mechanism, and perhaps of that portion of the great centre contained in the spinal cord. Nor can it be argued that the vascular tension is at once restored, even in part, by this portion of the vasomotor centre in the cord below the seat of injury; for it is well known from experiments on animals that, even after simple section through the spinal cord, no reflex movement of any kind can be excited for some time in any nerve that is dependent on the distal, severed portion. There is, further, an observation made by Weir Mitchell[1] to the effect that in the variety of the cerebral phenomena presented by cases of shock, there is evidence of a change, less constant in its effects than would be that of mere alteration in the amount of blood.

Nor is there any improbability in the suggestion that the peculiar power of inhibition, in which, as far as is known, all nerve structures share, and which is probably brought into play during the co-ordination of every nerve impulse, instead of only indirectly causing the symptoms of shock through its action on the vascular system, may be the direct and immediate agent influencing the nerves that govern sensation, motion, and volition, as much as those that control the walls of the bloodvessels. It has been shown beyond the shadow of doubt that, as a consequence of injury, the molecular motion which constitutes nerve force may be interfered with, perhaps even interrupted, in certain centres that control the heart and the vascular system; may it not be that the paralysis of motion and sensation, and the impairment of reflex action, instead of being merely secondary effects produced through the agency of the circulation, are also due, wholly or in part, to a similar interference with the molecular motion in other centres? and that shock is to be regarded as an extreme and general manifestation of that inhibition, with the power of which, as regards a few organs, physiology has made us acquainted? It is highly probable that many of the so-to-speak accessory consequences of injuries, the immediate dependence of which on the actual damage is not apparent, are due to some cause closely analogous to this; and especially is this true of injuries to the nerve centres, and of consequences that make their appearance at once and gradually disappear.

A powerful stimulus applied to a sensory nerve can entirely obliterate a slighter one. After laying open the spinal canal, irritation of the posterior roots is for some time followed by no result. After section through the spinal cord, reflex phenomena are not witnessed till the inhibitory influence is wearing off; and if when these have returned, and the animal has recovered as far as is consistent with the continuance of paraplegia, a second sec-

[1] New York Medical Journal, 1866.

tion is carried through, higher up, only those parts of the body are affected which are indebted for their innervation to the portion of cord above the original section—showing that it is only along nerve paths that the influence of shock can make itself felt; the lower limbs, in an experiment of this kind,[1] severed from all nerve connection with the part of the cord that has sustained the most recent injury, manifest no diminution whatever of reflex excitability, none of the symptoms of shock, only a contraction of their blood-vessels, secondary to and consequent on the loss of pressure in the rest of the body. More recently, Lewisson[2] has established, by means of experiments, that in a frog it is quite possible to suspend the activity of the reflex centres by the irritation of sensory nerves; that if the irritation be sufficiently powerful, this inhibition may be extended to the voluntary movements; and that finally, in a rabbit, by crushing the kidneys, uterus, bladder, or intestine, all control over the lower extremities may be abolished, the paralyzing influence continuing for some time after the cessation of the irritation, and lasting the longer in proportion to its violence. It is possible that these results, of such importance in this question, may be due to a condition of spinal anæmia; some experiments of Brown-Séquard,[3] showing the contraction of the vessels in the pia mater of the cord, resulting from such an injury to the abdominal viscera as passing a ligature round the hilus of a kidney, would point in this direction; but the result is not one which is material to the cause at issue, and the experiments are of such difficulty and have been repeated by subsequent observers with such slight success, that Vulpian at least considers it more than doubtful if the conclusions are justified. It remains that, as a result of injury, either directly involving the nervous centres or indirectly influencing them by the effect produced on distant organs (especially those of the abdomen), there may be produced in animals a condition which, after due allowance has been made for the difference in cerebral organization, cannot be distinguished in many of its features from that known as shock; and which not only finds in physiology its nearest and best known parallel in the effect produced on the circulation by the irritation, direct or reflex, of certain nerves, but actually presents this effect as one of its best marked symptoms. In short, shock is an example of reflex paralysis in the strictest and narrowest sense of the term—a reflex inhibition, probably in the majority of cases general, affecting all the functions of the nervous system, and not limited to the heart and vessels only.

Prognosis of Shock.—Reaction.

Shock may be fatal within the space of a few seconds, as in the example given above, or, as frequently happens in severe and extensive injuries, the patient may sink gradually, after a longer or shorter time, without any attempt at recovery. Even if reaction does set in within a reasonable period, and the longer the delay the greater the danger, all fear from this cause must not be laid aside; sometimes, it is true, recovery is gradual and uninterrupted; more often its course is much less uniform, fluctuations more or less alarming often being present; and sometimes, when all seems progressing favorably, the heart fails suddenly as if its reserve of strength had become exhausted, and the patient dies in very much the same way as in secondary asphyxia.

It is difficult to define the precise moment when reaction commences.

[1] Goltz, Pflüger's Archiv, 1875. [2] Quoted by Fischer, loc. cit.
[3] Archives Générales de Médecine, 5e série, tome viii. 1856.

Furneaux Jordan would place it very early, believing that there is in shock, at first, a diminished frequency of pulse that soon passes off, giving place to rapid and irregular action. The most satisfactory sign is an increase of strength in the heart's beat; this soon leads to diminished rapidity and more regular rhythm. Vomiting, especially if the stomach is full, is very common; but it should not continue, and must not be confounded with that sign of the persistence of shock, intense irritability of the stomach allowing nothing to remain there. Then the respiration becomes deeper and more even, the face loses its livid pallor, the countenance begins to show some expression, and the limbs, instead of lying helpless, are moved to more comfortable positions; but it is a long time, even if no fever sets in, before the will acquires its accustomed power; and it may be as much from this as from anything else that prolonged retention of urine is so often met with. In general, even if there has been no wound, reaction is marked by a certain amount of fever; the skin becomes hot and dry, the face flushed, the urine scanty and high colored, the pulse full and bounding, and there is thirst, with restlessness and headache. Where shock after accidents or operations has been severe, there is an attack of ordinary traumatic fever, varying with the nature of the accident, the method of its treatment, and the constitution of the patient, from a slight rise of temperature attended with the ordinary sleeplessness and constipation, to a condition of the most extreme excitement, rapidly running on to fatal exhaustion—that form to which Travers gave the name of "prostration with excitement;" then the languor that characterized the early stage passes, after a variable interval, into restlessness, jactitation, and precordial anxiety; often, but not always, there is delirium varying in degree from occasional incoherence to wild and fierce excitement, more frequently occurring and more marked during the night; at times the condition is scarcely distinguishable from that in an ordinary case of Delirium Tremens. Soon succeed exhaustion, marked by somnolency; a profuse chill and clammy sweat; a haggard and livid aspect; a small, irregular, or fluttering pulse; innumerably rapid, panting respirations; passive convulsions, hiccough, and subsultus; the stupor and stertor of apoplexy, and death.

The question of prognosis must be answered in each case mainly from the degree of the injury sustained: for, though shock is by no means wholly dependent on this, generally, in severe cases, there is either great injury or injury of some great part. Loss of the power of swallowing, showing that probably there has been inhibition of the glosso-pharyngeal centre in the medulla oblongata, in the immediate neighborhood of other centres indispensable to the maintenance of life; and insensibility of the conjunctiva, leading to the conclusion that the fifth pair of nerves has become implicated, must each of them be regarded as of the gravest import. Any hemorrhage, even if slight, is a complication much more dangerous than would at first be supposed, owing to the extreme depression of arterial tension already existing; the clinical observation made by Travers, with regard to the very serious import of the loss of even a small amount of blood in syncope or shock, has been demonstrated and explained by the physiological experiments of Tappeiner. The longer reaction is delayed, and the more incomplete and fluctuating it is, the more hopeless the case. Still, even in the worst, sometimes recovery does take place, against all hope, when the patient has lingered hours and even days in an almost lifeless state. Among conditions usually regarded as unfavorable, must be placed either extreme of life; and, of the two, advanced age as the most threatening; and similarly that condition of premature degeneration of which the abdominal viscera especially present such frequent examples.

In the case of operations, prognosis may often be rendered much more easy

and certain by a careful, previous study of a patient's habit of thought and feeling; whether he is hopeful and cheerful, looking forward to speedy recovery, or downcast and despondent, with a dogged conviction that cannot be reasoned with that things will not go well—a conviction in itself apparently enough to cause the worst result. For there are too many recorded cases of death after slight operations, and after perfectly natural labors, and even on a fixed day, for there to be any longer doubt as to the very grave addition that has to be made to the unfavorable features of a case, when the patient entertains a fixed idea that recovery is impossible. There are at least two distinct forms of mental influence which operate powerfully upon the result. The first is either the buoyancy produced by hope, and a firm belief in a successful issue; or the depression produced by despondency, and a rooted conviction that the result will be fatal. The second is either a calm and equable disposition, patient and enduring; or a peevish and irritable temper, restless and complaining. The former of these is usually influenced by age, the latter by sex. The young are the most hopeful, and women, as a rule, endure most patiently.[1]

Treatment of Shock.

Though it does not seem probable, in the present state of knowledge, that shock can be altogether prevented, especially when regard is had to the fortunately exceptional cases of very sudden death, yet undoubtedly, as far as operations are concerned, its severity may be in some measure diminished; and not only in cases of disease of long standing, in which amputation or excision may be required, and in which the state of health of the patient may have been already much modified by the confinement or the other conditions to which he has been subjected, but also in such operations as the removal of tumors, or lithotomy, when the patient, as far as can be ascertained, is in a condition of complete health, and no part of the body through long-continued suffering has come to bear an altered relation to the rest. The care taken in the preparation of a patient, accustoming him to altered rules and conditions of life, and rendering him familiar with persons and things about him, is labor well spent, even if light; and there is not a little in the conduct of the operation itself—the restraint of hemorrhage and the avoidance of cold or exposure while the patient is on the table, and of unnecessary delay during its performance. How far anæsthetics are of use in the prevention of shock, is a question that had best be considered with that of their advisability during its continuance. [Easley and McGuire recommend large doses of quinia, before an operation, as a means of preventing shock.]

In the treatment of a person suffering from severe shock after injury, the first care should be to loosen everything around the neck or chest, that can in any way impede respiration, and to place the body in a recumbent position, with the head as low as possible; even a pillow is not always advisable. Of course, any source of hemorrhage should be at once investigated, but, during shock at least, bleeding is not of common occurrence. And, above all things, it is necessary in every way to maintain the *temperature* of the body as near the normal degree as possible: as the circulation fails, the temperature falls; the bed and the room should be warmed, warm blankets and hot bottles should be placed around the patient, and the extremities should be well rubbed. It has even been recommended (and carried out successfully by Hunter, of Philadelphia) that patients when suffering from shock should be placed in a

[1] Savory, loc. cit.

hot bath, beginning at a temperature of 98° F., and gradually increasing it to 110° F. By leaving a patient in a bath in this way for a quarter of an hour, the temperature of the body has been raised from 96° F. to 98°.5 F., the respirations reduced in number from 36 to 20 in the minute, and the cold and clammy skin rendered warm and dry. When the heart shows signs of failing, external heat is sometimes of further use in the form of flannels or sponges wrung out of water as hot as can be borne, and applied to the cardiac and epigastric regions. Counter-irritation more vigorous than this is of questionable service, though there can be no doubt that sinapisms and blisters applied to the extremities can, by the irritation of sensory nerves, cause a slight elevation of the general blood-pressure. In persistent vomiting, a mustard-plaster may sometimes be applied, with very good effect, to the pit of the stomach.

The use of *stimulants* cannot be avoided in a severe case of shock. It is quite true that a patient may recover without their employment, but no one who has ever seen the color come back rapidly to a patient's face, or felt the pulse beat stronger at the wrist, after a small quantity of brandy has been swallowed, will hesitate again as to the propriety of their use. The quantity must be judged of individually in each case, but need never be great; if reaction is coming on fairly, and continuing evenly, very little is required; if the reverse be the case, and one or two ounces of brandy produce no effect, it is probable that it is not being absorbed by the stomach, and the ingestion of a further quantity would only result in causing vomiting. In this case, or where the power of swallowing has been lost, enemata of small volume containing brandy may be tried, or subcutaneous injections of brandy or of ether,[1] but usually, it must be confessed, with little hope. Afterwards, when reaction has fairly set in, there is no proof that stimulants are of much avail; nourishment of a more lasting character is required, but a very careful watch should be kept on the pulse, and a small quantity of brandy administered whenever this shows signs of failing, and repeated every half hour if need be. *Opium*, in some form or another, is nearly always required to allay pain and to procure rest; if this can be obtained, nourishment need not be pressed just at first. Opium seems of equal service, however given: by the mouth, by the rectum, or hypodermically; if it cause sickness when injected under the skin, it may be combined with atropia; or it may be given by the mouth, the required quantity, in form of the liquor opii sedativus, undiluted, being placed upon the tongue; or sometimes a freshly made pill of crude opium will answer the purpose when nothing else is successful.

It must be very seldom that a case presents such peculiar features that *artificial respiration* would be of any service; it is nearly always the heart that gives out first, and death from asphyxia, due to the lungs failing to act, must be very rare. *Transfusion* has been tried in a sufficient number of cases to prove its futility, as long as shock is unaccompanied by serious hemorrhage; when this is the case, the question rests on altogether different grounds. Up to a certain point, simple hemorrhage has scarcely any effect upon the blood-pressure, the vasomotor nerves causing the vessels to contract in proportion to the loss of the circulating fluid; but beyond that point the compensation fails, and the pressure falls with great suddenness. If, in a case of this nature, uncomplicated, transfusion be resorted to at this critical

[1] Verneuil (Journal de Méd. et de Chir. Pratiques, Mars, 1877) recommends subcutaneous injections of ether, 15 minims, repeated in an hour's time if required, stating that he has seen very great benefit derived from it. [The editor is confident that he has saved life, in cases of severe shock, by the hypodermic use of ether; it may be administered very freely, a syringeful (about 30 minims) being injected every five or ten minutes until the patient is able to swallow, when carbonate of ammonium, 5 grains every half-hour by the mouth, may be substituted.]

moment, a relatively small amount of blood may save the patient's life. But in shock, in which the vasomotor mechanism is almost, if not completely paralyzed, and in which the most serious symptoms, even death itself, may occur without the loss of a single drop of blood, the question is totally different. Injection of more blood only increases the amount stagnating, and does nothing to raise the pressure. The limits within which vascular tension is independent of the amount of blood, are very wide.

It has been suggested that in cases where the external jugular veins stand out prominently, and where presumably the right side of the heart is full of blood, *venesection* would be of some service, and might, by relieving the distension, stimulate the heart to fresh action. But this condition points to asphyxia, and not to shock; and in the face of the serious influence of accidental hemorrhage, can scarcely be advised. The heart is distended because it is paralyzed; not paralyzed because it is distended.

The intravenous injection of *ammonia* has been tried in a few cases with sufficient success to warrant a repetition of the experiment; by this means Penfold[1] probably saved a patient in extreme collapse from continuous purging; and Tibbits,[2] after trying it unsuccessfully in a case of septicæmia, and another of hemorrhage, brought around by its aid a very severe case of railway injury, in which the pulse at the wrist was quite imperceptible, and the patient had already lost all power of swallowing. The quantity injected at one time should not exceed ten minims of the liquor ammoniæ fortior, and care should be taken not to send it into the subcutaneous tissue; the degree of dilution is not, according to Halford, material. [As pointed out by Dr. Richardson, ammonia, whether given in this way or by the mouth, both acts as a stimulant and is useful by maintaining the fluidity of the blood, and thus obviating the risk of heart-clot—a pathological condition found in most of the cases of so-called "secondary shock."]

There are three drugs, *strychnia*, *belladonna*, and *digitalis*, the use of which, from their action on the blood-pressure and the vasomotor nerves, has been particularly recommended during the continuance of shock, in the hope of relieving at least one, and perhaps the most prominent symptom. Of these drugs, the last named is perhaps the most hopeful, from the power which it has been shown to possess both over the heart and the arterioles, diminishing the rapidity of contraction of the former, and increasing its strength, while at the same time it stimulates the muscular walls of the latter. It has, indeed, been employed by Dr. Wilks[3] for this purpose, in a case of shock following parturition: the patient was apparently *in articulo mortis;* her limbs were cold; her body in a state of deathly, clammy sweat; the face was livid; no pulse was to be felt at the wrist; and a mere fluttering was heard when the ear was placed over the region of the heart. Brandy and ether had been employed without any good effect, and, as dissolution was imminent, it was determined to try digitalis. Half-drachm doses of the tincture were given every hour; after four doses reaction set in, and after seven, complete recovery began. Dr. Lauder Brunton remarks on this case that a consideration of the encouraging results obtained can hardly fail to gain for digitalis a much more extensive application in cases of shock than it has hitherto received. Yet this mode of treatment does not seem to have been resorted to by others. Strychnia, which, like digitalis, may be given either by the mouth or subcutaneously, in cases of this kind, derives its chief recommendation from the result of experiments by Mayer[4] and Prokop Rokitanski,[5] showing the power

[1] Australian Medical Journal, January, 1873. [2] Med. Times and Gazette, November, 1872.
[3] Med. Times and Gazette, January, 1864.
[4] Med. Jahrbücher d. k.-k. Ges. d. Aertze zu Wien, 1872.
[5] Quoted by Brunton, Saint Bartholomew's Hospital Reports. 1879.

it possesses over both the vasomotor and the respiratory centres in the medulla oblongata and spinal cord; but actually, in the only case in which I am aware that it has been tried, the result was not satisfactory. Belladonna,[1] too, in very small, repeated doses, acting as a stimulant to the vasomotor system, is perhaps worthy of a trial.

With regard to the employment of an anæsthetic when an operation is required in a case of shock, and still more with regard to the choice of the particular substance to be used, there is very great diversity of opinion. On the whole, it may be said that the balance is at present decidedly in favor of the administration of these agents, and of ether rather than of chloroform. It is true, as Fischer has remarked, that patients seldom feel to any extent, and that sometimes, when no anæsthetic is administered, the pulse improves even during the operation; but the former statement is not worth much as an argument; and the latter is of no avail against the employment of ether. Indeed, the only objection that can be urged against the latter, is that in the ordinary methods of administering it, the supply of oxygen to the patient is too much interfered with. Chloroform, which is used, perhaps, less than it was, but is still preferred by some experienced administrators in these cases, is undoubtedly, when pressed at all far, an exceedingly dangerous agent; a minimum quantity is required to anæsthetize the patient, and only a drop or two occasionally to maintain the influence of the drug; anything over this, quite abolishing the action of the cerebral hemispheres, will be probably disastrous. For, as Brunton[2] has pointed out, the violent irritation of a sensory nerve affects the heart reflexly, but compensates itself by causing the small vessels to contract, and so raise the blood-pressure; if the quantity given is sufficient to do away with sensation completely, the compensating action is lost, and there is danger; if the chloroform is pushed further still, the reflex centre in the medulla inhibiting the heart becomes affected equally with the cerebral hemispheres, and the danger is past; and Brunton cites Syme as always having used chloroform with a free hand. But in shock there is certainly no need to proceed as far as this. A great deal has been said about the choice of the time for performing an operation; whether to operate at once, wait till reaction is commencing, or until it has fully set in? No doubt each case must be judged on its merits, but still some general rules may be laid down. The main guide, of course, is the severity of the shock sustained, as evidenced by the patient's pulse and general condition. If it is not severe, it need scarcely be regarded; if so grave that it is questionable whether reaction can set in, every means should be tried to bring the patient around before operation is attempted; in all other cases, it is probable that Guthrie's advice will be admitted by most at the present day to be the most reasonable: wait two, four, or six hours if need be, till the pulse is beginning to regain some of its strength, and till the patient is recovering sufficiently to become conscious of pain. [Some information may be gained by observing the temperature. If this be below 96° F. (35°.5 C., Redard), no operation should, as a rule, be performed.]

Fatty Embolism.

In discussing the symptoms of shock, it was mentioned that many of the fatal cases hitherto ascribed to its influence must be referred to some other cause—especially when after an injury or operation the patient continues to present a perfectly satisfactory condition for some hours or even days, and then, more or less suddenly, is seized with symptoms indicative of some great

[1] Gasquet, Practitioner, May, 1879. [2] British Medical Journal, December, 1875.

disturbance, and dies. It is not possible to understand how any effect of nerve influence that was caused by injury, could remain for two or even three days concealed so thoroughly that there should be no suspicion of its existence, and then manifest itself with such intensity and rapidity as to occasion death within a few hours. Some other explanation manifestly is required for such cases as these; and within the last few years it has, so it is believed, been found, for many at least, in what is known as Fatty Embolism, that is, embolism of the small arteries in the lungs, and very commonly in other organs, due to minute drops of fluid fat which, having been set free somewhere in the periphery (generally in connection with the medullary cavity of bones), are carried into the circulation and follow its ordinary course.

It was not, however, in connection with any case of injury that the existence of fatty embolism was first discovered; for the earliest observation[1] on record refers to a case of contracted kidney, in which the choroidal vessels were found to have been plugged with particles of fat supposed to have come from an atheromatous aorta; and in the next,[2] in which after severe injury to the bones the pulmonary vessels were loaded with fat, the significance of the lesion was quite missed; and when, shortly after this, Wagner[3] made a similar observation in two fatal cases of pyæmia, the suggestion was immediately raised that the fat was in some connection with the metamorphosis of pus at the periphery, and the development of metastatic abscesses in the lungs. Some experiments, in which the necessary conditions were not maintained, served to perpetuate this view till 1865, when Wagner[4] published the results of forty-eight cases in which he had found this lesion (fifteen of these being instances of rapid death after severe injury to the bones and soft parts); and Busch demonstrated by cinnabar injections that; immediately after injury to the medulla of bones, it was possible for particles of fat to enter the open mouths of the lacerated veins and be carried into the pulmonary arterioles, causing embolisms, without, however, necessarily entailing abscesses or inflammatory disturbance. From these facts, and from experiments by Bergmann[5] on the intravenous injection of oil, Wagner was led to the conclusion that the coexistence of fatty embolism with pyæmia was merely accidental; and since then it has been shown clearly that the very different results to which fatty embolism may lead, depend on whether it occurs after subcutaneous injury, or is due to some disturbance set up in the neighborhood of a septic wound.

The appearance that the lung presents is exceedingly suggestive of a process of embolism: if this has been very extensive, the smaller vessels may be so distended as to be visible to the naked eye, and hemorrhage or infarction may occur; while under the microscope, the lung-stroma shows a regular injection, mapping out all the capillaries and filling them with some liquid, which, from its reaction with perosmic acid and its rapid disappearance under ether, can be nothing else than fat. More often there is only a condition of hyperæmia and œdema, and then there may be found here and there, with tolerable regularity, minute drops and short cylinders. These changes are not limited to any part of the lung, though they occur, as might have been expected, most plentifully in the lower lobes. Not unfrequently oil-drops have been found in the clots in the branches of the pulmonary artery, in the right side of the heart, and in the large veins leading to it from the seat of injury. So that post-mortem evidence alone renders certain the presumption that the process is really one of embolism.

[1] Müller, Wurzburg med. Zeit., 1860.
[2] Zenker, Beitrag. z. norm. und path. Anat. d. Lunge, 1862.
[3] Wagner, Archiv d. Heilkunde, 1862. [4] Ibid. 1865
[5] Zur Lehre v. d. Fettembolie. Dorpat, 1863.

The nature of the accident or disease in which this complication arises, renders it still more clear: it is always one in which the rupture of fat-cells may reasonably be supposed to occur; and the greater the chance of this, the more extensive the embolism. This is probably the reason—joined to the fact that the veins are torn and cannot close—that it has been observed with such frequency after fractures; so frequently, indeed, that it has been said to be a normal occurrence. Thus it is always proportionate, in simple fractures, to the amount of injury inflicted on the medulla, and to the number and size of the bones that are broken; bearing out thoroughly the experiments of Vulpian,[1] who showed that in animals, while in simple fracture embolism was sometimes hard to find, yet, when a foreign body was introduced into the medulla, there never was any difficulty in tracing the fat through its whole course; while, if the foreign body was a tent, the lungs were simply gorged. But though most commonly met with after simple fractures, and perhaps in them of greatest clinical interest as offering an explanation for deaths that under ordinary conditions seem utterly unintelligible, fatty embolism is by no means confined to them. Many of Wagner's instances occurred in cases of compound fracture, and especially after secondary amputation, or were found after acute periostitis (when metastatic abscesses were nearly always present); while the lesion has been noticed after simple suppuration in the connective tissue; after crushing injuries of only the fleshy parts of the body, especially if they contained much adipose tissue; after rupture of fatty liver; in chronic inflammation connected with bone; as the result of fatty degeneration of thrombi; in icterus gravis, and in diabetes. Indeed, so common is it, that Flournoy,[2] examining all the bodies brought into the Pathological Institute at Strasbourg, found it in no less than ten per cent.

Quite a number of observers have seen, in compound fractures, oil-drops flowing out with blood from the medullary cavity, and have afterwards found similar ones in the veins leading from the limbs; but till recently it was believed that this was the only channel by which the fat was taken up; it is, however, clear, from fresh experiments,[3] that fatty embolism of the lungs may follow within a few hours if any oil gain access to a serous surface, and even, though at a much later date and to a much more limited extent, when it is set free in the connective-tissue spaces. The delay and the diminution may probably be accounted for by the fat having to pass through lymphatic glands on its way, and probably becoming emulsified in them.

It is not easy in all cases to account for the force which is necessary to cause the oil-drops to enter the veins; sometimes, perhaps, the nature of the accident itself will give a reason for it; in other cases, it has been suggested that the liquid fat from the broken-down cells stagnating in a wound, is suddenly caught up when the state of syncope passes off and the heart recovers; or it may be, as Vulpian's experiments suggest, that from the commencement of inflammation there is a sudden increase of pressure and local tension.

In studying the effect of fatty embolism, it is necessary to distinguish clearly between the results of clinical observation and the data furnished by experiment; for while in the latter every precaution can be taken to exclude other influences, there can be no question that, in the former, other things besides fat can gain access to the circulation. The most recent and careful experiments that have been conducted for the purpose of ascertaining the cause of death, are detailed by Scriba[4] in a monograph on this subject. By injecting carefully purified oil into the veins, into the medulla of bones, and

[1] Déjerine, Progrès Médical, 1879.
[2] Egli-Sinclair, Corresp.-Bl. f. Schweizerische Aerzte, No. vi., 1879.
[3] Wiener Archiv f. exper. Path., Bd. xi.
[4] Untersuchungen über die Fettembolie.

into the peritoneal cavity of rabbits, Scriba has been able to confirm the views of Bergmann,[1] that the symptoms depend mainly on the quantity injected and the rapidity with which it is introduced, or the proximity of the vein selected to the heart; in this way it is possible to vary the result from a death so instant as only to bear comparison with the injection of air into the veins, to the slightest possible dyspnœa; and even this may be wanting, though after death the fat may actually be found arrested in the lungs. Scriba finds, moreover, that, if the distance from the heart of the point of entrance of the fat into the circulation be at all great—as in the majority of fractures taking place in the human subject it would be—and if the force that propels it into the veins be slight, the quantity required to produce any alarming symptoms in an animal is very great; in no case is Scriba of opinion that death can be caused by the injection of less than three times the amount of blood present in the femur of an animal.

Further, much light has been thrown by experimentation on the ultimate destiny of the fat that is carried into the pulmonary capillaries—a point of great clinical significance; for it is not impossible that, in some cases, the particles may be carried off, and, by their subsequent impaction in other organs, cause even more serious mischief. Some undoubtedly pass at once, without any detention, through the pulmonary circulation, and either form emboli elsewhere, or are caught up by the glomeruli of the kidney and excreted with the urine; for, after injection of fat, large masses have been found in the urine and the vasa afferentia; glomeruli and tubules have been seen full of it, while the same condition has been detected after fractures in man. Indeed, from the intermittent appearance of oil in the urine, from its abundance for the first few days, and then its absence till the end of the second week, when it may appear again for a short time, Scriba concludes that in man, after the lapse of from six to eight days, the emboli become detached, and that they then pass on either to be excreted by the kidneys, or to be caught by the capillaries in other organs—these in their turn setting free the particles they originally detained to be carried into the veins, and so cause, as it were, secondary pulmonary embolism. It has happened, somewhat unfortunately, that in very many of the recorded cases no observations were made on the presence of oil in the capillaries of other organs; but it has been observed in the liver (though not to any large extent, possibly from the action of the hepatic cells which may take it up), and on several occasions[2] in the brain and spinal cord.

The symptoms characteristic of fatty embolism, when uncomplicated, besides the presence of oil in the urine at irregular intervals, and the dyspnœa, which of course varies with the number of capillaries obstructed, are a fall rather than a rise of temperature, slight hæmoptysis with irregular action of the heart, pallor and lividity of the skin, shallow respiration gradually passing into Cheyne-Stokes breathing as the case becomes worse, and loss of reflex excitability with, at times, spasms of various kinds, or paralyses. But it is very seldom that the symptoms met with after accidents or operations resemble these; much more often there is observed a condition of which an excellent example is given in a case related by Southam:[3] the operation (primary amputation of both lower extremities) was borne well; a comfortable night was passed; and the general condition was regarded as satisfactory, though the temperature had risen from 101°.2 F. the previous evening, to 103° F. in the morning. Suddenly, in the afternoon, the patient became restless and excited, his face wore a dusky look, his pulse and respiration

[1] Berliner klin. Wochenschrift, Aug. 18, 1873.
[2] Czerny, Berlin. klin. Wochenschrift, Nov. 1875.
[3] Lancet, July 10, 1880.

became more rapid and feeble, and, though there was no rigor or marked dyspnœa, by the evening the patient was delirious, sinking fast with a temperature still rising, and it was evident that the wounds were no longer aseptic. At the autopsy, though no change of importance was visible to the naked eye, yet microscopic examination showed the capillaries and arterioles of the lungs to be simply filled with oil globules. In nearly all the instances that have recently been reported at length, the symptoms resembled these. Boettscher[1] gives the particulars of a case of gunshot wound of the knee-joint, fatal on the third day from sudden collapse, and states that the lungs were intensely hyperæmic and full of fluid fat. Czerny's[2] case was somewhat different, in that it was one of simple fracture of the femur; but, like the rest, there was a gradual rise of temperature with sudden dyspnœa and cyanosis on the morning of the second day; post-mortem evidence of fatty embolism was abundant, not only in the lungs but in the brain, liver, and kidneys, all of which were studded with small ecchymoses. Déjèrine[3] gives the particulars of a case in which a leg was severely crushed, and which proved fatal within seven hours; but, though the lungs were full of oil, there had been no marked dyspnœa. In short, it seems impossible to reconcile the clinical data with the knowledge derived from experimentation; in the latter the conditions are known; in the former there must be something else to cause the rise of temperature and other symptoms.

It is not meant that fatty embolism does not take place after accidents, or that when it is extensive it is not dangerous from the effect which it must produce on the respiration and circulation, and perhaps from another cause recently pointed out, the solution of blood corpuscles by its agency; but that it is scarcely possible to conceive of its being so extreme as to obstruct the circulation through the lungs and so cause death; or so extensive as to bring on the same result by occluding small vessels in the brain or spinal cord—the conclusion at which Scriba arrived from the artificial production of uncomplicated fatty embolism in animals. It seems, on the whole, much more reasonable that it should be regarded either as an addition to that form of acute blood-poisoning known as "collapse with cyanosis," which is particularly likely to set in on the second or third day after an injury, and which is much more consonant with the symptoms in the majority of the cases; or, where the change has set in earlier, as a complication which, added to the already existing nervous prostration and the loss of blood, is sufficient to turn the scale. But a much wider series of observations is required before this question can be regarded as in any way definitely settled. Of its importance there can be no doubt; already upwards of one hundred and forty instances have been recorded in Germany alone, and the fatty embolism was, according to Egli-Sinclair, the cause of death in no less than thirteen per cent. of these.

Still less is known with regard to the significance of fatty embolism in diabetes. The occasional lactescent state of the blood serum in this disease, has long been known; and recently[4] it has been shown to be due to the presence of fine molecules of oil; and fatty embolism of the lungs and kidneys, exactly similar to that appearing after fractures, has been found in a patient dying in that condition of coma which is not uncommon towards the end of this affection. But the relation existing between these conditions is quite uncertain; death in a state of coma, with an enormous increase in the amount of molecular oil in the blood, is at least quite consistent[5] with the complete absence of fatty embolism.

[1] Dorpat. med. Zeitschrift, 1877, S. 326.
[2] Berliner klin. Wochenschrift, Nov. 1878.
[3] Progrès Médical, 1879.
[4] Edinburgh Med. Journal, 1879.
[5] Gamgee, Physiological Chemistry, p. 171.

TRAUMATIC DELIRIUM AND DELIRIUM TREMENS.

BY

WILLIAM HUNT, M.D.,

SENIOR SURGEON TO THE PENNSYLVANIA HOSPITAL, PHILADELPHIA.

Traumatic Delirium.

The word Delirium has rather a curious derivation from *de* (from), and *lira* (a ridge between two furrows). The Latin verb *deliro* is defined as "to make a balk in plowing." A free translation, therefore, would be to deviate or wander from a prescribed line. Hence the word "wandering," that is often used to express the presence of delirium in disease. Those who coined the word did better than they knew, if our present knowledge of the brain and its functions is taken into account. As knowledge of the localization of nerve centres and their conducting fibres becomes more and more developed, we can readily understand how the furrows and ridges and folds of nerve matter may be disturbed by a balk of the driver (external impression), or by a stump in the furrow (internal disease). A temporary derangement of the intellectual and perceptive faculties, manifested through the speech and actions of the patient, is the necessary characteristic of delirium. The wandering need not be by speech alone, for a deaf mute, or an aphasiac, may become as delirious as any one else, and delirium is unquestionably experienced by, and may be produced in, animals.

Continuous or chronic delirium necessarily becomes *insanity*, and technically should be considered under that head. The case may be a fatal one, as far as the individual patient is concerned, and the delirium, in a more or less acute form, may be continuous until his death; but should he survive, and the delirium persist indefinitely, his place would be among the insane. This temporary character of true delirium varies in its expression to a remarkable degree. Sometimes it shows itself as a mere passing fancy, and is difficult to detect; again, the patient may be perfectly himself as long as his attention is directed by another, or to some special object, but, these conditions ceasing, he relapses into his absurd utterances or actions. Then moments, and sometimes extended periods, of normal consciousness follow, during which he will be more or less aware of what has passed, and will own to himself, or to his attendants, that he has been "making a fool of himself," and will declare that he will not do it again. Soon, however, there is a recurrence of the wandering and the nonsense, and, should the disease get the upper hand, these may continue in a more aggravated form and without intermission until death. The actions of the patient also vary very much, and range from trivial deviations from the normal standard, such as it would require an expert to detect, to the most violent efforts, threatening injury to himself and to his caretakers.

Anatomy of Delirium.—Delirium is eminently one of those conditions to which the convenient word "functional" is applicable, when we seek for an explanation of its phenomena. It manifests itself, as far as we know, through impressions made upon the cortical gray substance of the brain. The cells and fibres of this substance, therefore, must be in a receptive condition, and need not of themselves deviate from the normal state. In fact, a perfectly healthy cortical matter, if the received physiological views of its purposes are correct, is more consistent with the occurrence of the severest forms of delirium than one which is otherwise. Its functions are disturbed by its environment, in the form of meningeal inflammations, or by slight irritative exudations or hemorrhages pressing upon it. Great pressure would suppress its workings altogether. Again, it may be harassed from without by alterations in the quantity and quality of the blood which is sent to it, and which may be charged with the products of disease, or overloaded with poisons. Then the special senses, being set agog from the same causes, bring wrong impressions to it, which it must needs take up and discharge, in the form of wrong thought, wrong talk, and wrong action. The necessity of this receptive faculty of the gray matter for the production of delirium, is further proved by the meagre mention of delirium as a symptom, when the brain itself, excepting the cortex, has been made the subject of experiment or clinical observation.[1]

Thus in lesions of the *Pons*, a tendency to cry more than to laugh is noted. There is emotional weakness, which might be taken for hysteria, but no mention of delirium. The *Crura* being disturbed, paralysis of the third nerve follows, and the diplopia and confusion of vision thus caused, together with a certain confusion of speech, probably owing to some facial paralysis, may readily give rise to the idea that delirium is present, when really the intellectual faculties are undisturbed. After the first effects of a lesion of the *corpus striatum* are over, the absence of mental disturbance is particularly noted. There may be slight thickness of speech and also emotional phenomena, but no delirium. Injury of the *thalamus* is attended by less distinct signs than injury of the striate bodies; but delirium is not noted as one of its symptoms. Injuries of the *white substance* of the hemispheres are not productive of delirium, nor do I find it mentioned as belonging to lesions purposely inflicted upon the *cerebellum*. The posterior and inferior parts of the *frontal lobes*, being injured, give rise to typical aphasia, and a careless observer might construe its manifestations as those of delirium.

Certain portions of the *cortical gray matter*, then, of the surfaces of the hemispheres and their convolutions, being subjected to irritative influences, are the seats of delirium. These remarks are confirmed by clinical observation. It is to be understood that delirium may coexist with affections or injuries of some of the other regions above mentioned, but when it does so, there is every reason to believe that, in most cases, it is due to the neighboring meninges being more or less involved. Dr. Morris Longstreth informs me that he has analyzed the histories of more than three hundred brain tumors, and that delirium is rarely mentioned as one of their features, and that, when it is, it may be readily accounted for by implication of the membranes, these in their turn affecting the cortical matter. When formerly Demonstrator of Anatomy in the University of Pennsylvania, I have no doubt that I showed many splendid brains, the original possessors of which had been "mad as March hares." The supply of subjects was large, and many of them must have come from the "Insane Wards" of the Almshouse. I can call to mind glued membranes, masses of old lymph, pearly arachnoids, and

[1] Carpenter, Bastian, Ferrier, Charcot.

ossific deposits; but, these being removed, I sliced and dissected and lectured upon as pretty brains as an enthusiast in anatomy would wish to see. I remember one in which the old lymph mass was so extensive, that it actually formed a secondary membrane covering both hemispheres; and yet beneath was a beautiful brain. What havoc must have been caused to the intellectual and perceptive demonstrations of the cells of the cortex!

My own clinical observations incline me to agree with those (Hughlings Jackson and others) who think that the posterior lobes of the hemispheres have more to do with ordinary intellectual processes than the anterior. A very large number of cases of injury of the cortex have come under my care, and I have frequently noted and spoken of the almost absolute indifference in this respect with which enormous injuries to the frontal lobes are borne. I have seen masses of brain come away from these, and also from the middle lobes, without any apparent intellectual disturbance. If the case were fatal, delirium would come on towards the end, there having been ample time for the irritation to spread; but, recovery following the injury, I have known the patient to convalesce without a single incoherent manifestation. In fact, I am disposed to think that in such cases recovery is the rule rather than the exception. I am sure, however, that this is not so when the posterior lobes are the seats of cortical injury. Delirium then often sets in at once, and may cease as pressure from hemorrhage or effusion increases, but, this being removed by operation or absorption, is apt to return, and will abate or increase in accordance with the progress to recovery or death. These injuries, therefore, are much more dangerous to life and to mind than the others. Inflammatory products, effusions, hyperæmia and anæmia, alterations in quality as well as quantity of blood supply, are then more potent causes of the symptom delirium, than pathological changes in the nerve substance proper.

Causes of Traumatic Delirium.—The foregoing remarks have necessarily included the consideration of those forms of traumatic delirium which accompany immediate injuries to the brain substance and its membranes. By far the greater number of cases of delirium coming under the notice of the surgeon, as well as of the physician, arise from causes external to the brain, and consequently have their origin in anything which may affect the quality or quantity of the blood. Of these, those affecting the quality are the most numerous, and hence immediate delirium is not nearly so common in external, surgical cases, as the delirium which ensues after time enough has elapsed to bring about various septic changes.

One cause of immediate delirium is great and sudden *hemorrhage*. This variety generally finds expression in a mild form of rambling, that is more apt to be indicative of pleasant sensations than otherwise. Should fainting occur, sufficient to check the bleeding, and if, in the mean time, surgical appliances be successfully used to prevent its recurrence, the patient reacts, sometimes very rapidly, and will often speak regretfully of the glories through which he has passed. If the case prove to be a fatal one, a distressing restlessness sets in, and this with the delirium continues until death.

There is a rather rare form of immediate traumatic delirium, which nevertheless must be more or less familiar to every surgeon of a great accident hospital, or to those who are in any position, as upon the battle field, where they become familiar with severe and sudden casualties. Delirium might appear to some to be a misnomer, for the characteristic is that every word and idea are perfectly coherent. There is great exaltation of mind, but an utter want of appreciation of the bodily injuries. Commonly the spine has been involved in the crush, and the line of communication with the brain has been cut off, but this is not necessarily the case. There is no collapse at first: the skin has its

normal temperature, the pulse is full and rather frequent, the face may be more flushed than natural, the eyes bright, and the expression good.

The surgeon enters a ward some morning, after a terrible accident has occurred, and finds that a victim of this kind has just been brought in and laid upon a bed. He is at once recognized by the patient as one in authority. "How are you, doctor," he says, in a high voice; "what have they brought me here for? I'm not hurt! No, sir! Look at that," and out goes an arm with the force of a prize fighter delivering a crusher. "Look here," and he tries to lift a leg, which his sensorium falsely tells him he has done, although his expression may indicate a vague and passing doubt. "Why there's my wife! Molly, what are you doing here? don't cry; what are you crying for? I'm not hurt; go home to the children and tell them I'll be there to supper and at the mills to-morrow. Won't I, doctor? Go home!" Soon this great tension gives way, collapse comes on, and by night the patient is in another home than that in which he promised to be. I have never known such a case to recover.

With all its coherence, with every intellectual and perceptive process correct as far as external matters are concerned, every word and thought as to other persons and objects right, everything as to himself wrong, how are we to classify this state, except as one of delirium? Important questions might arise as to the testamentary capacity of such persons; from what I have seen and described, there is nothing in their condition inconsistent with full ability to direct the management of their estates and effects.

Shock after injury is a condition so intimately involving the nervous system, both cerebro-spinal and organic, that delirium might be reasonably looked for as a common accompaniment of it. This symptom, however, is rarely present during the stage to which the term shock is applicable. The intellectual and perceptive faculties simply experience the profound depression which is present everywhere. The nearly pulseless, pale, cold body; the dull eyes and drooping lids; the slow and feeble respiration, and the shrunken and clammy skin, are all expressive of that general condition, in which the brain itself takes part. In fact, shock without reaction means death, and many die in this condition. During its continuance, there may be some slight mutterings, which increase if death is to come; but upon being spoken to, it will be found that the patient's intelligence is retained, and only sluggish. He wishes to be let alone, is indifferent as to what it all means, becomes colder and weaker, and dies; or warms up, it may be sleeps for a short time, and lives. It is in this latter event, when reaction is taking place, that delirium frequently occurs. It is apt to be wild, especially in children. Its degree is in accordance with the rapidity of return of the general functions. The rebound oversteps the mark, and disturbance of the cortex is one of the results. Fortunately this kind of delirium does not often last long. As the skin, kidneys, and other organs resume their normal actions, it subsides. Delirium may recur in the future progress of the case, but will have other causes for its production than what happened at the start.

Embolism of the cerebral vessels, from the suddenness with which it sometimes takes place, one would think would be a cause of immediate delirium. I do not, however, find this mentioned as a prominent symptom, or even as an ordinary one, in cases where the lesion is suspected. It may be that the limited area of cortex which is supplied by the special vessel or vessels involved, is nourished sufficiently from collateral sources to maintain its integrity, or that, if the blood is entirely cut off, local death of the delicate cells and fibres takes place so rapidly that their receptive and demonstrative properties are lost at once. *Thrombosis*, from the comparative slowness with which it mostly occurs, would be more likely to be accompanied by delirium; but as the vessels of the brain involved in this process are generally large and

basal ones, their influence upon the cortex is remote, so that the symptom is not one of special note.

I recently had the rare opportunity of observing the invasion of an attack of apoplexy in which the lesion, I think, must have been in the pons, although no autopsy was allowed to confirm the opinion. When I first saw the patient, she was entirely sensible, but in a high state of emotional excitement. She complained much of lateral and posterior headache. There was *no delirium:* answers to questions were promptly and properly given—but there was great restlessness in addition to the excitement; paralysis was not then present, for various acts were performed as requested. Knowing something of the patient, I was inclined to regard the attack as hysterical, and to prescribe and leave the house. Fortunately I remained, for soon quiet came on, the countenance became suffused with redness, stertorous respiration began and grew worse, and death took place in a few hours. Probably a basal thrombus had been slowly forming, which was finally followed by rupture; and it may be that some peculiarities, which we are apt to call hysterical, had, in this case, their origin in a pathological condition which was not a recent one.

Immediate delirium may also be brought on by so-called subjective sensations arising from irritations or injuries of the *nerves of special sense.* The particular parts of the cortex (supposed by some to be chiefly in the posterior lobes of the hemispheres) which have to take up impressions from these nerves and discharge them as perceptions, know nothing else than to develop these perceptions as objective truths to the intellect. Should these apparent truths assume distorted, frightful, or absurd forms, it is easy to understand how the confusion created would upset the centres of congruity and produce delirium. I have already spoken of the fact that some authorities are disposed to give the cortex of the posterior lobes of the hemispheres the preference over the anterior ones, as seats of intellectual processes. May it not be that the more intimate relations of the former with the phenomena of perception, and the close connection of these phenomena with the ordinary manifestations of intellect, bring their operations more readily under observation; and that deeper or abstract ideation has its nerve centres in the anterior lobes, these requiring for their accommodation those cranial forms which give to higher man "the front of Jove himself?" Comparative anatomy and the doctrine of evolution both appear to sustain this view. As to delirium, the clinical facts which I have related about injuries to the cortex of the frontal and posterior lobes of the hemispheres, also support it. Delirium does not deal with the abstract, but is developed in its highest degree by disordered perceptions sending false impressions through their transmitters, which in turn disorder the receivers. Whatever the middle lobes may have to do with ideation, the fact of their being the seat of centres through which the will produces motor acts, seems to be well established. I have one important clinical observation to sustain this view.

In Ferrier on "The Functions of the Brain,"[1] there is a drawing of the surfaces of the hemispheres to illustrate the effects of local electrization. One of the parts mentioned occupies the adjacent margins of the ascending frontal and ascending parietal convolutions, and this statement is made in regard to a certain part when it was the subject of experiment, "Retraction with adduction of the opposite arm, the palm being directed backwards." Now there was a sailor under my care, in 1879, whose case I have fully reported.[2] While at sea, he had inflicted very serious injuries upon the middle lobes of his brain, by fracturing his skull with repeated blows of an axe whilst he was, there is every reason to believe, in the delirium of heat fever and exhaustion. The delirium actually disappeared after he picked the pieces of bone away. The patient landed in New York

[1] London, 1876, p. 142.
[2] Medical News and Library, Philadelphia, July, 1879.

four or five days afterwards, came on to Philadelphia, and walked to the hospital. He was perfectly conscious and very intelligent. Soon there was paralysis of the left arm, with retraction (position of palm not noted), and then paralysis of the leg of the same side followed. On dressing the wound, two pieces of bone respectively a quarter by half an inch and three-quarters by three-eighths of an inch in size, were found under the anterior right margin of the sound bone, and *precisely*, it is fair to say, *in the position which Dr. Ferrier pictures.* Upon removing these pieces, the paralysis at once disappeared from the arm, and by the next day it was gone from the leg. There was no active delirium at any time after the patient's admission to the hospital. I recall the fact that I ordered him to the basement of the building, fearing that he would throw himself from the window should delirium come on. After having been there one night, he protested against it; said he was perfectly himself, and begged to be removed to his room up stairs. His request was complied with, and he remained quiet and rational until a day or two before death, when coma came on without antecedent delirium. As the brain became more and more disorganized, the paralysis returned and became general. He lived twenty-four days after the removal of the pieces of bone, and forty days from the time of the original injury. The lesion here was in the middle lobes; a very extensive abscess had formed, and the softening had extended as deeply as the corpus callosum.

Immediate traumatic delirium, it might be reasonably inferred, would be among the symptoms following the *bites of poisonous serpents.* Besides the specific virus, there are the elements of horror and fright to aid in its production. Experience, however, does not at all confirm such an inference. Deaths from snake-bite are preceded by stupor and coma,but delirium rarely exists, even for a short time. This is true not only as to fatal cases, but also as to those which end in recovery. A very large number of cases of snake-bite are reported by Sir J. Fayrer, in his splendid work, "The Thanatophidia of India." I have looked carefully over these reports, and have not once detected the word delirium; yet there was everything to suggest it. The words fright, depression, lethargy, stupor, coma, and unconsciousness, are continually used in the descriptions. But, until these last phenomena occurred, the intelligence of the victims appears to have been remarkably good. In some cases it took a few minutes to kill, and in others hours; in one doubtful case, nine days; and yet no delirium is mentioned. As Sir J. Fayrer says, the poison "kills by annihilating the source of nerve force." He mentions the fact that pyaemia may arise, when the patient lives long enough to have a suppurating wound from the bite. Then of course delirium might exist as a consequence of this affection, but I do not think that any case in which it occurred is given. Fright is sometimes so excessive as to bring the patient near unto death, and we are told to encourage and cheer him as a part of the treatment. This of course would be useless if he were in a state of delirium. The same may be said of cases of *rattlesnake* poisoning. Dr. R. M. McClellan, who lived for some years in a part of Georgia where rattlesnakes are very common, tells me that he has seen from ten to fifteen cases of persons bitten by them. The nervous symptoms, as from the bites of the Indian serpents, were those of stupor and coma, but there was no delirium. Even enormous amounts of whiskey, used as a remedy, would not occasion the excitement of drunkenness. Dr. E. B. Shapleigh treated a case of rattlesnake bite which occurred in this city (Philadelphia). The patient was rational throughout his brief illness, and made his will twenty minutes before his death. Dr. Weir Mitchell, who made some years since an exhaustive study of the effects of rattlesnake bites, also confirms these views. These observations are of practical value. If intense hysterical excitement, approximating delirium, or even delirium itself, should follow in the case of a person supposed to have been bitten by a poisonous snake, there would be almost a certainty that the

accident had not happened. Sir J. Fayrer, indeed, relates one case in which the patient was almost frightened to death, but recovered rapidly on its being found that the snake which had bitten him was not poisonous.

The bites and stings of certain *venomous spiders* and *insects*, not being so overpowering as those of serpents, might possibly give rise to delirium. A sort of delirium is described as following the bite of the tarantula; but there is reason to believe that much, if not all, that is related about this creature is fabulous. Death sometimes follows the stings of bees, wasps, or hornets. In such cases, there is nothing more likely than that delirium should arise, both from the pain and from the extent of surface affected. There is a condition produced analogous to erysipelas, and, if extensive enough, high febrile excitement with consequent delirium might occur.

The furious stage in *hydrophobia* is one that might be classed with delirium, from its temporary character, and yet during the paroxysm, when phrensy appears to possess the brain, there is a mental clearness inconsistent with the idea of delirium. The derangement expresses itself in acts rather than words; incongruous thought is not a part of it, for the patient seems fully aware of what is going on, though he has no power of will to control his deeds. A low and true delirium, indicative of exhaustion, may come on as death approaches.

In *tetanus*, there is no delirium. Even during the most violent spasms, the mind remains perfectly clear. The excito-motor and sensitive tracts of the cord, both direct and reflex, are strained to their utmost, whilst the cortex, unhappily maintaining its integrity, does its full part here in the development of suffering.

In *chorea*, there is no delirium even when the subjects of it have received most severe injuries, or have undergone operations. I have reported a case[1] of fracture in such a patient, who actually died from the exhaustion of his incessant movements and the consequent irritation of the broken fragments of bone. His brain was a perfect one. What morbid force kept up the involuntary motor excitement, I do not know; but it was certainly not expended on the cells of the cortex.

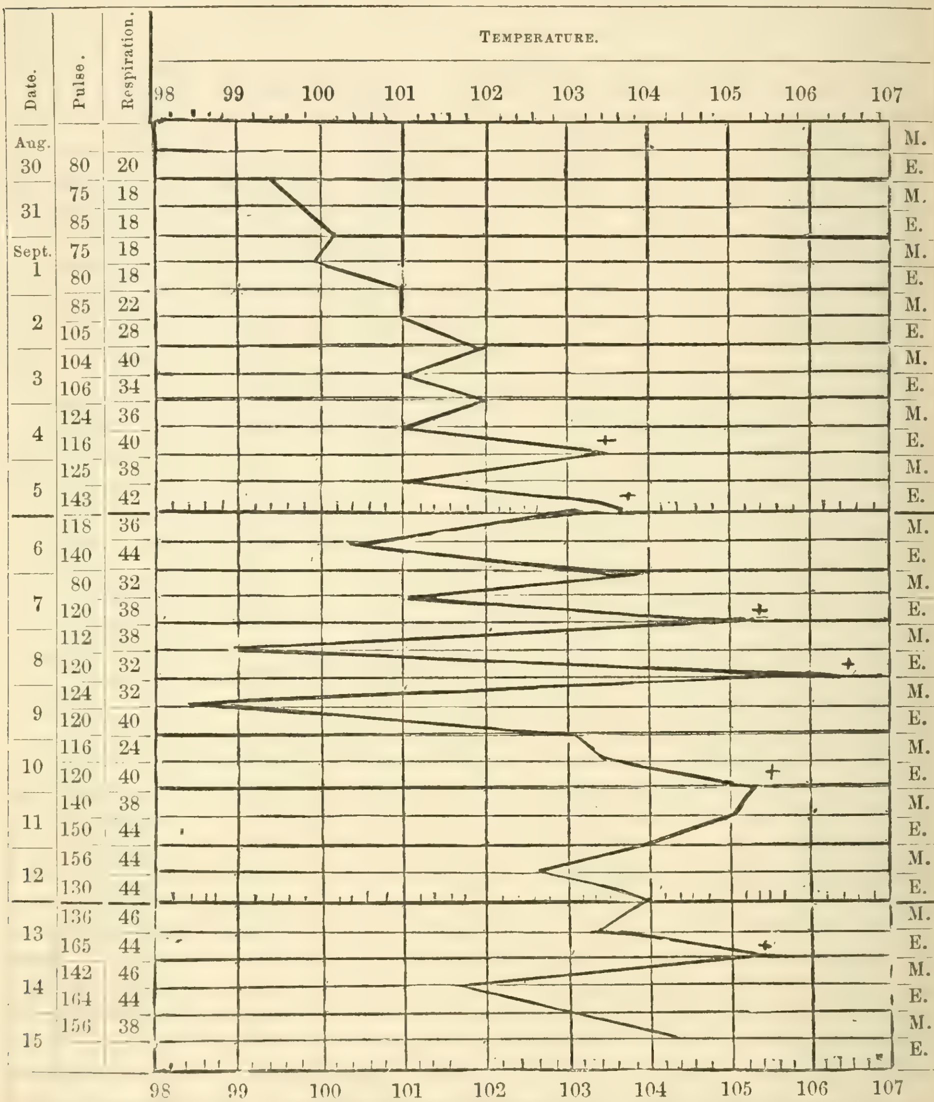
Sometimes traumatic delirium comes on shortly after *capital surgical operations* have been performed on account of severe injuries. This is much more apt to be the case with children than with adults, and it is also more likely to follow operations for recent, than those for old, injuries, or than those for disease. The symptom is a very bad one. After eliminating any cause which might exist for a short time, such as fright, the effects of the anæsthetic, etc., if the delirium should continue and increase in severity, a fatal prognosis would be justified. Delirium in disease is a very common symptom with children, the slightest fever being sufficient to cause it in some instances. Being creatures of perception rather than judgment, the brain balance is in them readily disturbed; and if such a trivial cause as a little rise in temperature is able to do this, how great must be the disturbance which may follow a serious injury, combined with a serious operation. I can give no better illustration of this than the annexed chart (Fig. 28) of the history of a case of compound luxation of the elbow-joint requiring excision. One may see at a glance how temperature, pulse, and respiration, moved nearly *pari passu* until the tenth day; then, exhaustion following the intense excitement, there was great recession, with chill, after which, new force being gathered, the delirium became more violent, and only ceased with the collapse of death.

Surgical or traumatic fever is very apt to be accompanied with delirium. By this term I mean that fever which is almost a necessary consequence of

[1] Pennsylvania Hospital Reports, 1869.

great operations or severe injuries, such as compound fractures. The phrase is often inadvertently used for the fever of the various septicæmias. This is wrong, for there is nothing of a septic character analogous to those conditions about it. The phenomena of fever are set up from the great local irritation.

Fig. 28.



Temperature chart of M. N., aged 10. Traumatic delirium following excision of elbow for compound dislocation. The (+) indicates a rise of temperature after a chill. The operation was performed on August 30, 1880. The delirium, which began on September 4 (sixth day) and persisted until the patient's death, was throughout very noisy and violent, with distressing hallucinations. The treatment consisted in the administration of bromide of potassium, morphia, and assafœtida.

Temperature rises, as does also the pulse; possibly there is an accumulation of combustible products. The quickened circulation and the heated blood play upon the gray cells of the cortex, and hallucinations and delirium

are the consequence, the vagaries not unfrequently having reference to the functions of the affected part. These symptoms mostly subside after active suppuration has been established, but sometimes death occurs before this happens. How truthfully a case of this kind is described by Dr. John Brown, in "Rab and and his Friends."

"Ailie's right breast had been amputated—one night she had fallen quiet, and as we hoped asleep; her eyes were shut. We put down the gas and sat watching her. Suddenly she sat up in bed, and taking a bed-gown which was lying on it rolled up, she held it eagerly to her breast—to the right side. We could see her eyes bright with surprising tenderness and joy, bending over this bundle of clothes. She held it as a woman holds her sucking child; opening out her night-gown impatiently, and holding it close and brooding over it, and murmuring foolish little words as over one whom his mother comforteth, and who sucks and is satisfied. It was pitiful and strange to see her wasted, dying look, keen and yet vague—her immense love. 'Preserve me!' groaned James, giving way. And then she rocked backward and forward, as if to make it sleep, hushing it, and wasting on it her infinite fondness. 'Wae's me, doctor; I declare she's thinking it's that bairn.' 'What bairn?' 'The only bairn we ever had, our wee Mysie; and she's in the kingdom forty years and mair.' It was plainly true; the pain in the breast telling its urgent story to a bewildered, ruined brain, was misread and mistaken; it suggested to her the uneasiness of a breast full of milk, and then the child; and so again once more they were together, and she had her ain sweet Mysie in her bosom."

The record of a favorable case of surgical fever with traumatic delirium, after operation, is here presented. (Fig. 29.) The age of this man had doubtless something to do with the symptoms, for it should be noted that persons over 65 or 70 years old are almost if not quite as liable to be affected with delirium, after great injuries or operations, as children. The form of delirium is generally like that set down in the chart.

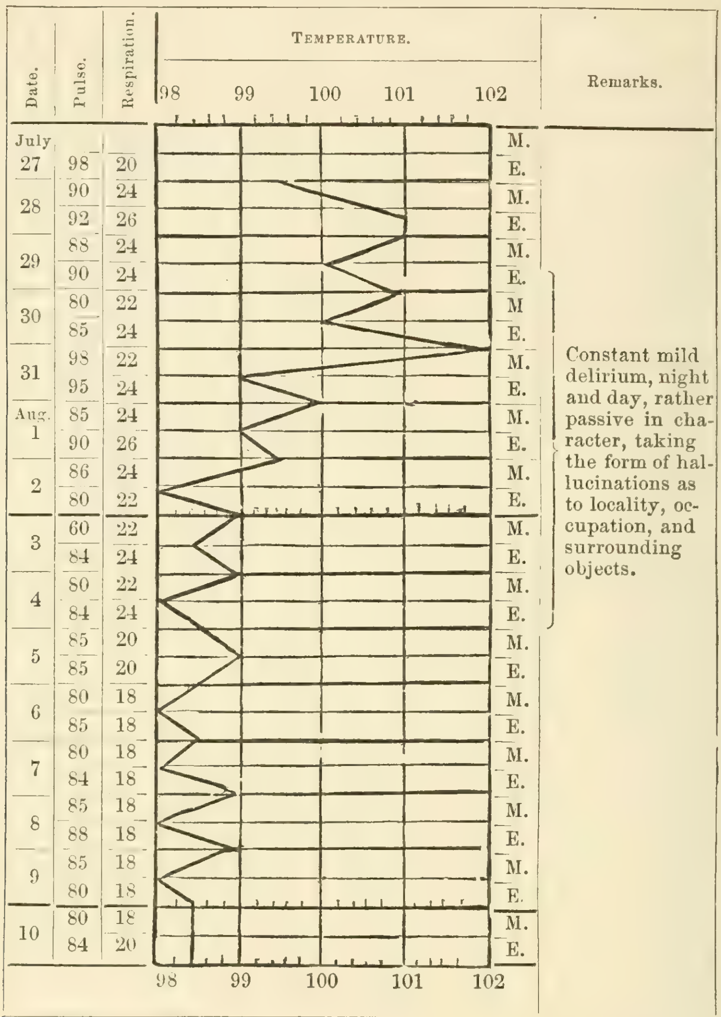
Independently of operations, *compound fractures* are very apt to be accompanied by delirium, after a few days from the time of the accident. Fortunately, except in cases complicated with the effects of drink, which will be considered under the head of delirium tremens, the delirium is not apt to be violent, at least in adults. During febrile exacerbation, it takes the form of mild wandering, which is not accompanied by uncontrollable acts. It may be that the local injury is a constant reminder, through pain inflicted by movement, and that thus the judgment is enabled, in a marked degree, to control the wandering senses. This form of delirium is not at all serious in its import. It gradually subsides, and is not apt to return without some extraordinary cause. As in almost everything else, the patient becomes accustomed to his own condition and to his surroundings. Then fever may occur, as, for example, during the separation of a piece of bone, but the brain will be wholly indifferent to it.

Simple fractures in the old not unfrequently give rise to delirium, which is also not violent in form, but much more serious in its indications than that which I have just described. Senile delirium is always a bad symptom in surgical cases, especially so when comparatively simple causes give rise to it. It indicates an inherent weakness, not only in the brain itself, which is probably affected by reason of deterioration of its bloodvessels, but also in other important structures, which are undergoing the alterations of age.

Extensive *lacerated wounds* will often give rise to delirium, which may last but a short time, the accompanying fever being ephemeral in character and scarcely worthy the title of surgical fever. I have the chart of such a case, which gives the record of what followed a lacerated wound of the forearm in a woman 38 years of age. On the day of the accident, the temperature rose from $98\frac{1}{2}°$ to $103\frac{1}{2}°$ F. On the third day, 104° F. was recorded in the

evening. After this there was a recession, and the normal standard was reached on the ninth day. There was passive delirium at night, but the

Fig. 29.



Temperature chart of J. A., aged 67. Traumatic delirium following amputation of hand for machine injury. Treatment consisted in the administration of 20 grains of bromide of potassium with 5 drops of the tincture of digitalis every four hours, and the hypodermic injection of a quarter of a grain of morphia at night. Recovery.

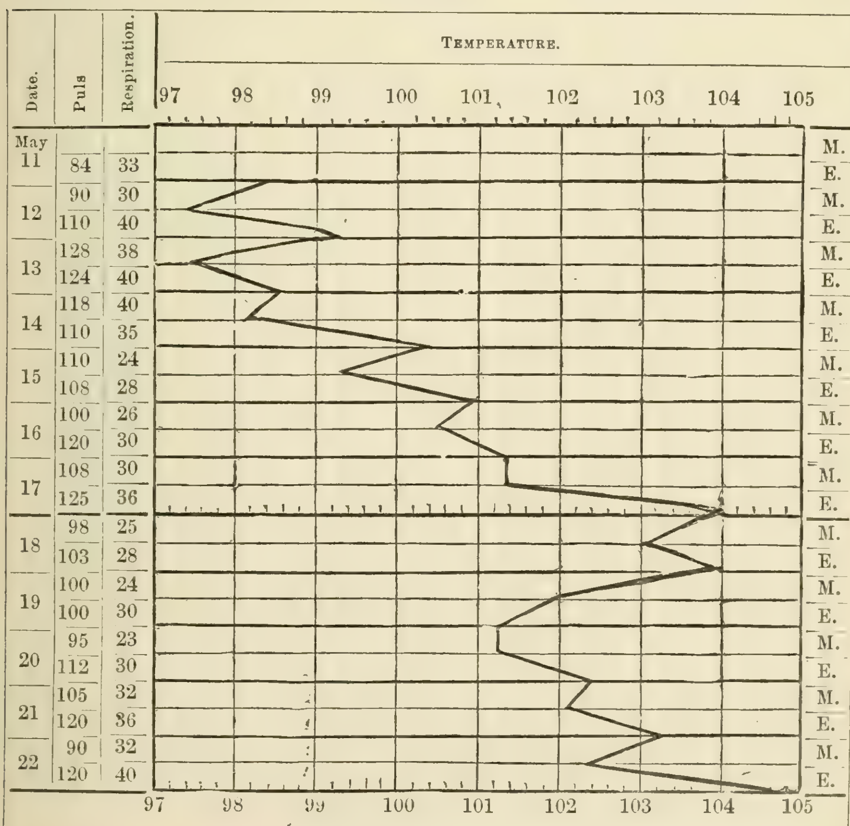
patient was rational in the daytime. Throughout, the wound was doing well, and a rapid recovery ensued. Such favorable progress of lacerated wounds is not, however, always to be looked for, when as high temperatures as 104° F. are found to exist. One would reasonably fear an excess of inflammatory action, which might be followed by gangrene. The sudden rise in the above case is a matter of note, for, instead of being alarming, it, with the delirium, simply pointed to the fact that the patient, although an adult, had the susceptibility of a child. There was nothing about the wound to account for it. Lacerated wounds in their ordinary progress may be the causes of true surgical fever, with accompanying delirium.

Burns and scalds are probably more apt to be attended with delirium than any other class of injuries. In rapidly fatal cases, where there is no reaction from shock, the brain is generally clear, and remains so until death. During this time, all susceptibility to pain having been lost, and the sense of touch being gone through the destruction of its principal organ, the skin, the intelligence takes no cognizance of the vast calamity. I have seen, after deep and extensive burns, what seemed to be a living soul looking out of a crisp, charred, and dead body. I have seen a child thus burnt playing with toys an hour before its death. Sometimes, in this condition, there is what appears to be a pleasant and mild delirium.

> "Death having preyed upon the outward parts,
> Leaves them insensible ; and his siege is now
> Against the mind, the which he pricks and wounds
> With many legions of strange fantasies ;
> Which in their throng and press to that last hold,
> Confound themselves. 'Tis strange that death should sing."

A much greater mercy is extended to these than to those whose burns are inevitably fatal, and yet who survive the shock for days, weeks, and it may

Fig. 30.



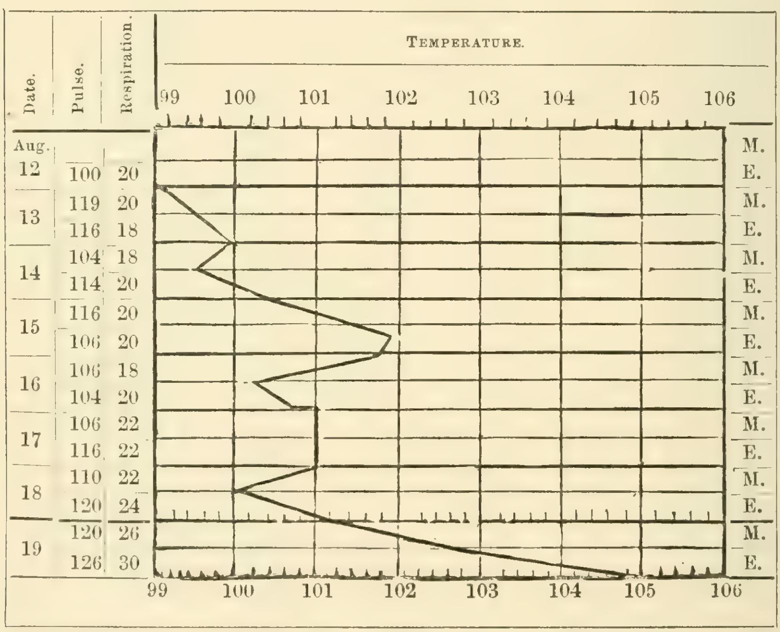
Temperature chart of E. K., aged 37. Traumatic delirium following extensive burns of face, neck, arms, hands, and trunk, involving skin and superficial fascia. From May 14 until the patient's death, the delirium was active and constant, requiring mechanical restraint. The treatment consisted in the administration of 20 grains of bromide of potassium, with 10 grains of chloral hydrate, and 5 drops of the tincture of digitalis, every four hours.

be for months. Is it any wonder that these patients all become delirious, and that in some the symptom is continuous until the end? Those who recover, also have delirium, which varies in extent and duration with the severity of the injuries. Touch, the master sense, of which all other special senses are modifications, and without which no knowledge of the external world is conceivable, is terribly deranged, and expresses itself to the sensorium only as pain. Myriads of fibres as conveyers, myriads of cells as receivers, are involved. There is so much wrong at the surface, that it would be a marvel if wrong did not follow at the centre. I should much sooner expect to find irritative exudations on the posterior surfaces of the cortex in fatal burns, than ulcers in the duodenum.

Besides pain, as a producer of delirium in burns, surgical fever, with its ordinary phenomena, may also set in and develop it. This, however, is not often the case, for it is surprising to notice, after the surfaces have become clean and the papillæ well covered with healthy granulations, how tolerant the patient becomes; and when repair is fully in progress, he passes on to a slow recovery without any mental disturbance.

I have the charts of six burnt and scalded patients before me, all of whom had delirium. Four of these recovered and two died. One of the fatal cases illustrates a burn and the other a scald. These two charts (Figs. 30, 31) are

Fig. 31.



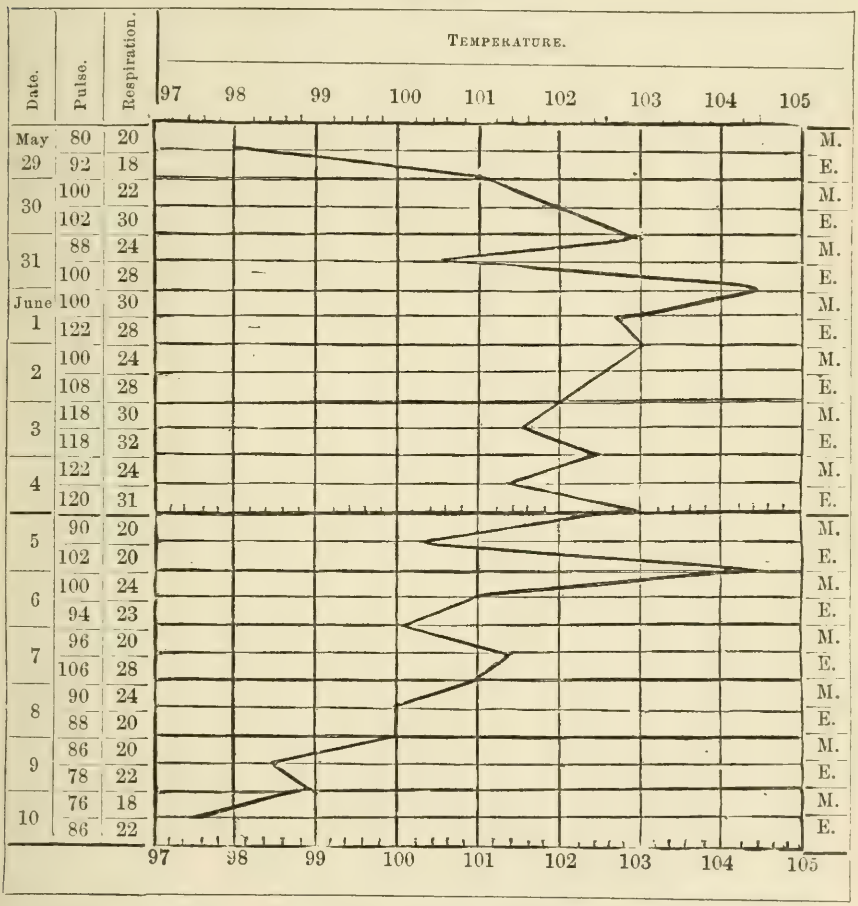
Temperature chart of P. M., aged 23. Traumatic delirium following scalds of face, neck, forearms, hands, and air-passages (by inhalation). Violent raving delirium began on August 13 (second day), and continued day and night, until the patient's death, requiring mechanical restraint. The treatment consisted in the administration of 30 grains of bromide of potassium with 10 drops of the tincture of digitalis every four hours; of 10 grains of chloral hydrate every six hours; and of half a grain of morphia, hypodermically, at night.

annexed, as well as one (Fig. 32) of recovery from burn. In two, the delirium set in on the second, and in the other on the fourth day, certainly too soon I think in all of them, and at least in the first two, for ordinary surgical fever. There was no delirium tremens in these cases. The absolute and quick de-

struction of the papillary surface of the derm is not so apt to take place in fatal scalds, as in fatal burns. Hence a sudden delirium in the former may subside, after complete insensibility of the part occurs.

Erysipelas is a fruitful source of delirium. Place and extent have their influences in producing it. When the disease is in the face and scalp, active delirium may set in very promptly. There is no doubt, I think, that contiguity and similar blood supply, giving rise to meningeal congestions, have

Fig. 32.



Temperature chart of L. J., aged 21. Traumatic delirium following superficial and deep burns of face, neck, arms, forearms, hands, legs, and feet. From May 30 (second day) to June 6 (ninth day) there was delirium, mild during the day, but noisy and requiring mechanical restraint at night. The patient was rational on June 8. The treatment consisted in the administration of 30 grains of bromide of potassium every five hours, with 15 grains of chloral hydrate at night, and a quarter of a grain of morphia when required. Recovery.

much to do with the production of delirium under these circumstances, and that in the early stage the brain is more irritated by these conditions than by the presence of any specific poisonous products. It is at such times that blood-letting, if resorted to at all, is admissible. When much surface is involved by erysipelas, in other portions of the body, we have conditions analogous to those of an extensive superficial burn, and, as a consequence, delirium, generally of an active character, is produced. In phlegmonous erysipelas,

where the cellular tissue besides the skin is the seat of great inflammation and destruction, the blood no doubt becomes loaded with septic materials. Delirium, often very wild at first, is not uncommon. If the case is to end fatally, a state very like that of pyæmia is developed, and, as the patient grows weaker, the disordered brain expresses itself in low, indistinct and unmeaning mutterings.

Epileptic patients, becoming the subjects of injury, are not, according to my observation, more prone to delirium than others. In fact, I have seen some cases in which the brain irritability appeared to be arrested or suspended for a time by reason of casualty. Whilst writing this article, a rare and curious case came under observation in the Pennsylvania Hospital.

A man was admitted for an accident requiring excision of the right elbow-joint. A few mornings after the operation, he was found to be having an attack of *catalepsy*. His eyes were open and fixed; his head was motionless; no answers to questions were given. One leg was raised: it remained fixed and rigid in the air. The same was the case with the other leg, and also with the left arm. Where they were placed, the limbs stayed until they were put down on the bed. The mouth also could be opened and fixed in any position which it was capable of taking. The patellar tendon-reflex was present in a limited degree, but the groin or scrotal reflex was marked. There was complete anæsthesia; no notice was taken of pins or pinchings. While I was in the ward, the man was observed to turn his head; I went to him; he was awake, but in delirium. This delirium expressed itself in delusions as to place. He could give a true account of his injury, and the name of the railroad on the line of which it happened. He himself, however, was on top of a pole; then in a churchyard; then in the building of the Pennsylvania Insurance Company; then on top of a railing. His occupation had nothing to do with these places. Being in the insurance company's building might have been suggested by his being told that he was in the Pennsylvania Hospital. The attack soon passed off, and on the third day the patient was entirely himself. He said that he had been subject to vivid and troublesome dreams, but both he and his wife declared that he had never before had a cataleptic fit, at least to their knowledge.

In *hectic*, there is no delirium. Its absence, indeed, is the great fact that serves to distinguish hectic from other febrile troubles which occur in the course of surgical, as well as of medical cases. Why the cerebral system is so exempt from contamination in hectic is difficult to explain. There are continuous febrile conditions with exacerbations, many constant and morbid tissue changes giving rise to products that would seem to have all the elements about them necessary to poison the blood, and so to work damage on the delicate cells of the cortex; there are exhausting discharges; excruciating pains often, as of the joints; colliquative sweatings and skin irritations enough to set a giant mad, and yet never an approach to delirium. This fact is so generally recognized, that when delirium arises in a hectic patient, some accidental cause, as for instance an intercurrent erysipelas, will be found to explain it, and when this is over the usual course is resumed. The freedom from delirium cannot be explained by assuming that tubercular and allied products are non-irritating in their character, for when, as in tuberculous meningitis, the cortex becomes directly concerned, there is marked, often violent and continuous, delirium, of a character that suggests something peculiar as its cause, and that is not explained merely by the local congestion. In this disease also, there is rarely time for the development of hectic. In hectic it is said that there is no *materies morbi* introduced into the blood from without, and that the products of tissue waste are carried off by the emunctories with such regularity and rapidity, that there is no accumulation of deleterious material in the circulation. This is an ingenious explanation, but not altogether satisfactory. It certainly favors the theory that causes giving rise to

hectic are local in their origin, and are not due to antecedent blood contaminations. It also helps to sustain the view that other febrile conditions, as the septicæmias, must have peculiar causes to originate them, these generally arising from without in the shape of organic germs, or animal poisons.

It is in cases of this latter kind that we do have delirium, and their number is probably greater than that of any other class in medicine and surgery. It is certainly so during wars and pestilence. Badly ventilated and crowded tenements; poorly constructed hospitals; abodes of any kind presenting errors in drainage, in sewerage, in location (as of camps); wherever, in fact, masses of men are brought together, under unfavorable, and sometimes in apparently favorable, conditions, there, wounds or disease arising, the "pure brain, by the idle comments that it makes," too often "foretells the ending of mortality," for "the life of all the blood is touched corruptibly." Immense advance has been made of late in checking the rise and progress of these "preventible diseases." It is too much to believe that they will eventually disappear, for the conditions for their production are constantly arising anew, or are being reproduced in places where it was thought that they had been abated or stamped out. *Pyæmia*, *phlebitis*, low forms of *erysipelas*, *gangrene*, *malignant pustule*, *phagedæna*, *carbuncle*, any, indeed, of the diseases which from their very nature generate certain blood poisons, and produce febrile states analogous to those called typhoid or typhus, come under this head. They are truly classified as blood poisons, or septicæmias, and when developed to any extent, they one and all give rise to delirium. This delirium is sometimes active, but is mostly of a passive character. When active, the brain membranes are probably the seat of local inflammations, which may arise early in the disease, and which are of very serious significance. The high excitement may be continuous until collapse and death occur. I have seen cases of this kind, but they are rare. Mostly, days elapse before delirium becomes a prominent symptom. It will appear during the febrile paroxysms, and pass away with them. If the case goes on from bad to worse, it will become continuous, and express itself in vague mutterings as long as the patient is left to himself. He will, however, answer questions correctly, and take food without resistance, and sometimes with avidity. He soon lapses, loses his sense of locality, and "wants to go home;" then he becomes altogether unconscious, apparently more from exhaustion than from deep coma, for he babbles and mutters almost until he dies. Given the conditions, there is scarcely a form of surgical affection, in itself mild or severe, that may not take on the above characters. This is especially true as to all cases in which there are open or abraded surfaces, either simple or complicated, and this fact goes far to sustain the germ theory, however unproved it may be.

In such a disease as *cancer*, we find that there is no delirium in its progress, that is, none belonging to it because of the cancer; and yet what is more professionally and popularly thought to be a peculiarly infecting disease than this? As in the case of hectic, there is enough to produce delirium, but I do not remember to have seen a cancerous patient thus affected. We call the disease malignant, and so it is; but it rarely appears to express its malignancy on the gray cells of the cortex.

Diagnosis of Traumatic Delirium.—Delirium declares itself, and hence there is nothing very profound to be said as to its diagnosis. It is the *kind* that requires discrimination, for restraint may have to be used, or else there must be great watchfulness on the part of the attendants. Ordinary delirium should be carefully distinguished from delirium tremens—a matter which will be discussed on a subsequent page. Sometimes delirium may be *assumed*. He would be a consummate malingerer who could keep up the deception for

any length of time. The coincident febrile or other symptoms would be wanting, and, by throwing the patient off his guard, it could very soon be shown whether or not he was in his right mind. A counterfeit delirium or wildness sometimes occurs in hysteria, often very difficult or impossible to tell from the real thing. In such cases time alone will develop the truth.

Treatment of Traumatic Delirium.—Delirium being a symptom, its treatment naturally consists in measures to remove the cause. In by far the greater number of surgical cases, where it exists, this is the course pursued. Sometimes, however, the symptom becomes so prominent, and so disturbing to what is being done for the main affection, that especial means are required to allay it. Indeed it is not uncommon to have to almost, if not altogether, abandon the original treatment for a while, and to address remedial measures wholly to the delirium. In the very active forms, cupping on the back of the neck, cold by ice-bags to the head, and free purgation with salines are required. Hot mustard foot baths are of great use, and may be readily given to the patient while lying in bed, should there be no surgical disability of the lower extremities. The bromide of potassium, or other bromides, may be administered in large doses. Opium is too much feared, and certainly should not be discarded altogether, as is done by some surgeons. Chloral hydrate is also of great use. Sometimes the necessities of the case may call for the use of ether or chloroform by inhalation. In the passive forms of delirium, requiring interference, depleting measures are not well borne. Good nourishment and stimulants, together with moderate doses of opium, will be found to allay the violence, if not entirely to prevent the occurrence, of the symptom in ordinary cases. Of course, nothing is to be gained by directing remedies especially to the delirium immediately preceding death, unless it should be very violent, which is not common. At the beginning of delirium, quiet, as absolute as possible, and isolation, are great factors for good. There should be no suggestive conversations with the patient, or with others in his hearing, for these might readily lead to unfortunate acts. A statement, interesting in this connection, has been recently published in the medical journals. The delirious patients of one doctor, in a hospital, were found to have a great propensity to throw themselves out of the windows, and had to be carefully watched. The other doctors' patients were free from this tendency. A medical man was taken sick in the hospital, and became delirious. He was under the care of the first doctor. He reported afterwards that this doctor was in the habit of giving directions about guarding the windows, in the hearing of his patients. The sick man went through the same experience, and declared that, during his delirium, the impulse to throw himself from the window was so irresistible, that he would have done so had he not been guarded.

Delirium Tremens.

In a "tract" upon this subject, written "by Thomas Sutton, M.D., of the Royal College of Physicians, and Physician to the Forces" (London, 1813), the author says: "Delirium tremens, and likewise the treatment, which will be pointed out as we proceed, are known to some professional men to a certain extent; but to many they are wholly unknown; and the disease has not yet taken a station in medical writings." In his practice between 1798 and 1807, the doctor "was led to see the distinction between phrenitis and delirium tremens, at least in regard to the treatment."

These remarks are introduced to show how comparatively late in the history of medicine, a distinctive recognition was made between meningitis or

phrenitis, and delirium tremens, the latter having for its production a specific cause, and a pathological anatomy entirely distinct from that of the former. From the earliest times, excess in drink has been a habit among men, and it seems scarcely credible that the effects of this habit in producing a peculiar disease of the brain and its membranes, should for so long a time have escaped attention. Was it because everybody drank, and was drinking considered so innocent a pastime that it was not thought of as a cause of disease? This also is incredible, for the evils of drink, as well as its pleasures, are dilated upon by the authors of all ages and countries. It is probable therefore that drink was known to be a cause of disease, but that the effects were misinterpreted, and were considered to be evidences of active inflammation. This was no doubt so, for the treatment of these cases was antiphlogistic to an extreme degree, and the mortality was frightful. A great advance, then, was made when it was recognized, both by the effects of treatment and by the results of post-mortem examinations, that a true inflammation did not exist in this disease. Dr. Sutton was at first on the phrenitis side. He naïvely says: "The one party, with myself, considering the disorder to be active inflammation of the brain or its investing membranes, conducted the treatment according to this supposition; the other, without pretending to any precise notions of this affection, in so far as the contents of the cranium might be concerned, were in the habit of using opium in large and repeated doses. *I very soon perceived that the latter practice carried with it all the success.*"

The post-mortem appearances, as far as the contents of the cranium are concerned, are peculiar in this, that they show no sign of active inflammation, nor of any of its products. Instead of adhering membranes, thickenings, opacities, and pus, there is a condition, so characteristic in uncomplicated cases, that it has been named "wet brain." Passive congestion and serosity, the latter both subarachnoid, in and under the pia mater, and filling the ventricles and following the convolutions, are what are met with. The brain substance proper is not necessarily the seat of changes; and what happens to it in fatal cases must be secondary, and not essential to the disease, else how could it be possible for so many to recover entirely from this affection, and, provided that there be no return to former habits, to pass their lives without showing any defect in mind or body? In fact, what was said about traumatic delirium and delirium in general, is equally applicable here. A sound cortex, capable of being impressed by adverse influences, is in the best state to develop delirium. Repeated drafts upon this soundness, by renewed attacks, will finally affect it, and the victim will then too often lapse into imbecility or dementia.

Causes of Delirium Tremens.—Delirium tremens then, as far as its production is concerned, does not differ from other forms of delirium. The difference lies in the peculiar effects arising from the cause. The great interest of medical men in this disease is due to its frequency, through the universal prevalence of drinking habits. There is no disease or injury upon which it may not make its imprint, and give a serious turn to what would otherwise be favorable. In many cases, both medical and surgical, all else has to be abandoned in treatment until the delirium is subdued. Thus delirium tremens is not only a torment in itself, but, when it complicates other affections, it is an unbounded torment to all concerned.

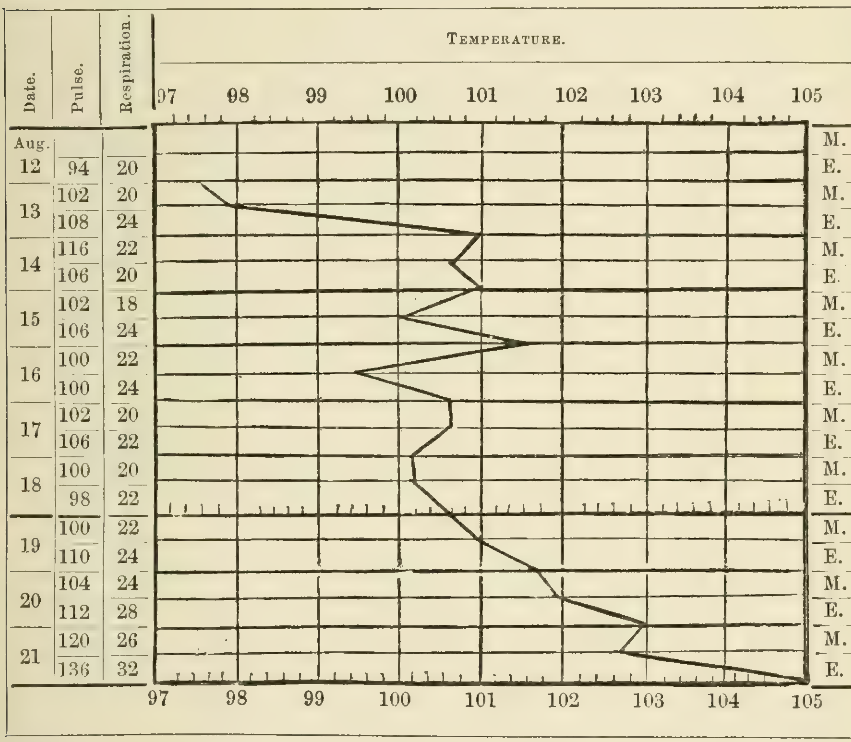
The cause is nearly always the excessive use of *alcoholic drinks*. The habitual use of other articles is said to produce it: opium, belladonna, stramonium, tobacco, cannabis indica, certain fungi, and even tea and coffee are all capable of causing delirium. Of these, it is said that veritable delirium

tremens is sometimes produced by *opium* and *tobacco*, and cases may be found in medical works in proof of the fact. I have seen one case of poisoning with *stramonium*. There were hallucinations and much severe delirium, with visual anomalies, but, the cause being well known, the symptoms soon subsided under treatment with emetics. Overdoses of *belladonna* produce like effects, and sometimes there is furious delirium. It is not common for either of the two last-mentioned drugs to be used habitually; a necessity, it would seem, for the production of delirium tremens by any substance capable of causing it. *Cannabis indica* is habitually used in the East, mostly in the form of the well-known haschish. It is said "to pervert the natural perception of objects and their normal conditions and relations, more than any other agent." If so, one would think that in time phenomena like those of delirium tremens might readily follow its use. I have one observation to record as to its curious power of producing double consciousness, an *alter ego*. I was giving it to a patient for some chest trouble. He was wholly ignorant of what he was taking. One day he said to me: "Doctor, you will have to stop giving me that medicine; I don't know what it is, but here am I, John, on this lounge, talking to myself, John, sitting on that chair. I can't stand it, and if you keep on I shall be wild." The symptom disappeared on discontinuing the medicine. Had one side of the brain the power to so project an *ego*, that the other side could take cognizance of it? Singleness as to both external objects and ideas, seems to be the result of the actions of our double cerebral organs, or centres, in a normal condition. When perverted by disease or intoxicating agents, this particular property might be disturbed, and such curious results as that just related might be produced. Anæsthetics, such as ether and chloroform, it is well known sometimes cause violent delirium. This may occur at the start, and not return, but now and then a case is met with in which delirium persists after an operation has been performed. I have known it to so continue, and to be apparently the exciting cause of an attack of delirium tremens, of which the remote and continuing occasion was an under stratum of rum.

It is not my intention to consider here all substances that might possibly cause delirium tremens. The above-mentioned are the most prominent. For practical purposes, delirium tremens caused by the habitual use of alcoholic drinks is what demands the attention of the surgeon. The disease, as proved from post-mortem examinations, and also from the results of various modes of treatment, is one of depression of the organic forces, although it may express itself by intense animal excitement, and hence the source of those mistaken views already alluded to, which regarded it as a true phrenitis. It is thought by many to be caused by the withdrawal of accustomed stimulus. This may sometimes be so, but the truth more likely lies in the fact that, at the time of the attack, there is a rebellion of the overtaxed digestive organs. The stomach becomes sickened, the liver refuses to act properly, the bowels are torpid, the kidneys are irregular in action and, with "old stagers," are often so altered by disease as to give rise to temporary suppression of urine. Thus the various results of vicious tissue-metamorphosis, besides those of alcohol, to which they also are due, poison the blood, and produce through the circulation, and probably by direct contact with the cortex, the peculiar form of delirium under consideration. There is no doubt that in many accident-cases, the sudden stopping of the drinking habit will develop the disease. That is to say that, without the accident, the patient would not have had the attack; but here the casualty may itself have been a prime cause of depression, and thus have produced that state which allows the effects of the habit to declare themselves and to gain the upper hand.

Delirium Tremens and Mania a Potu.—It is important to distinguish between delirium tremens proper, and that wild, acute delirium, which is the result of a grand "spree," *the delirium ebriosorum*, the true *mania a potu*. The surgeon often meets with these cases, as wounds of all kinds are not unfrequently received during the debauch. All stages are exhibited by these patients, from the "remorse that weeps, to the rage that roars." They mostly require to be kept from injuring themselves and others, until the immediate effects of the overdoses of alcohol are over, when there is rarely any difficulty in taking care of them. Below is a chart (Fig. 33) of a case of this kind.

Fig. 33.



Temperature chart of H. M., aged 35. Mania a potu after scalds of face, neck, scalp, forearms, hands and ankles. This patient was doing very well, though with high temperature, until twenty-four hours before his death, when, his friends having poisoned him with very bad whiskey which they had smuggled into the hospital, he was attacked with mania a potu, and, after a night and a day of the most acute, active delirium, died from exhaustion. The treatment consisted in the administration of large doses of bromide of potassium, chloral hydrate, and sulphate of morphia.

The cause given, the suddenness of the attack, and the nature of the injuries, also themselves prone to produce delirium, mark it as one of true mania a potu. The chart points almost with certainty to the time when the smuggled whiskey begun its work of death. The rise of temperature was steady, the attack furious, and the termination rapidly fatal.

Symptoms of Delirium Tremens.—The trembling, watchful, wakeful, suspicious, cowardly, busy subject of an attack of delirium tremens, is almost too well known to need description. His hallucinations are without number. He sees rats, rams, snakes, monkeys, cats, bats, bugs, spiders, mice, lice, imps,

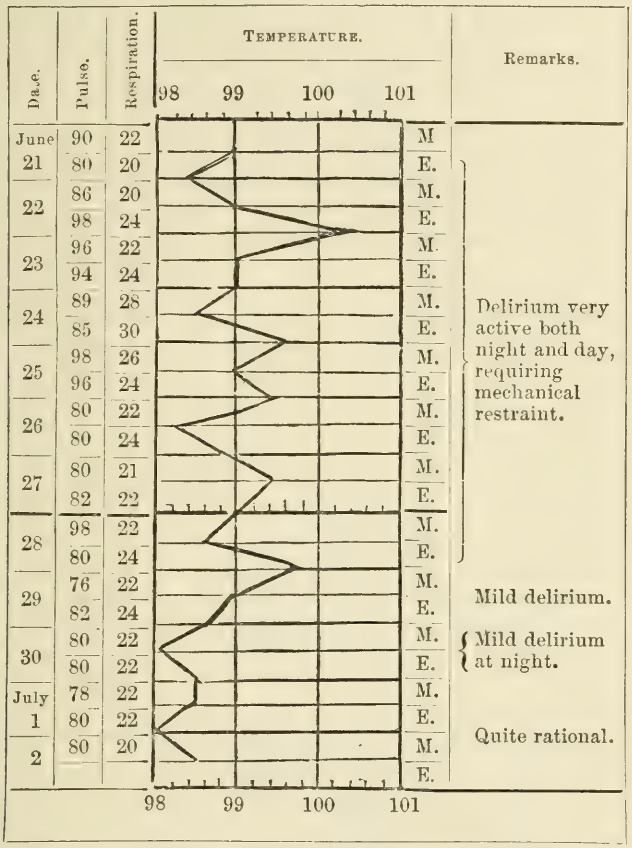
demons and furies, dancers and devils—but not often angels, as the illusions are rarely pleasant. They are, however, sometimes comical, frequenly obscene, often sad, but generally horrible. The patient is subject to attacks from without, and is constantly shrinking from them, having no courage to defend himself. Somebody or something is going to kill him, and fiends are doing their best to prevent him from attending to the most important business, with which he is also constantly occupied. Sometimes this business has to do with the real occupation of the patient, at other times it is wholly imaginary. I have known a teamster, with a bad fracture, to lie in bed and drive his mules and horses all day, with loud curses and imaginary lashings. A broker will rave of the stocks, and a merchant of the markets; but mostly, when sifted, this all-important business will be found to be about the most trivial and absurd matters. Not unfrequently, and especially in the beginning, the delusions are only about one thing, or upon one subject; thus, an officer who had been through the late war, was perfectly straight as to everybody and everything else about him, except a long tin foot-warmer, which had been placed at his feet in bed and covered up. The mound thus made suggested a body and a coffin, and it was at once converted into the mortal remains of the patient's companion in arms, over which he sat up in bed and gave the most pathetic but maudlin discourse. Again the patient may experience great compunction, and mingle the touching and the sad with the ludicrous. I call to mind one who, amid his vagaries, stopped to thank the leeches which had been applied to his badly sprained ankle, for drawing different kinds of liquor from him; a lively fellow was taking his fill of champagne, and a sodden chap indulged in ale; while a regular soaker, who fell off motionless, got dead drunk on whiskey. If the attack be not arrested by sleep, the delusions are no longer temporary, but continuous, and assume sometimes a distressing, and at other times a violent form. Death is usually caused by exhaustion; always so when there is no complication of organic disease or injury.

A layman may imagine how such an interloper as delirium tremens must interfere with satisfactory surgical practice, but no one but a surgeon can appreciate the fact. It plays havoc with all his calculations. It displaces well adjusted fractures, reproduces dislocations, tears open wounds, disturbs dressings of all kinds, removes ligatures and sutures, makes simple injuries compound and complex, sets up irritative abscesses and exudations, and so opens the door for erysipelas and pyæmia; in fact it is a fiend, sitting like a cormorant hard by the surgeon's efforts, and devouring all his measures for good. It might be thought that the pain produced by constant movement of injured parts would be a reminder, as is sometimes the case in traumatic delirium, and call the wandering senses to order. But it is one of the features of delirium tremens, well under way, that the patient is wholly oblivious to pain when injuries are inflicted upon him by himself. He will often howl with fear or agony at what the surgeon does, but within an hour may be grinding the ends of his broken bones together as though they were mill stones, while at the same time his busy brain will be working foolishness. I have known two men with broken legs to get up and have a fight. It is not at all uncommon to see a man with a broken leg, whose habits have not been suspected, giving the first signs of an attack of delirium by getting out of bed with his apparatus on, and walking about the room or ward. These facts are explanations of the seeming contradiction, that a man in delirium tremens is an arrant coward, and yet will cut his own throat or shoot himself if he gets a chance. Sometimes he maims himself dreadfully and deliberately, without any idea of suicide. I know of one who coolly cut away his genital organs,

piece by piece, and fed the ducks with them. Pain, not being felt, or at least regarded, is no hindrance to the act of self-wounding.

I shall illustrate delirium tremens as to its special clinical features in surgical cases, by the three following charts (Figs. 34, 35, 36), which may be called typical.

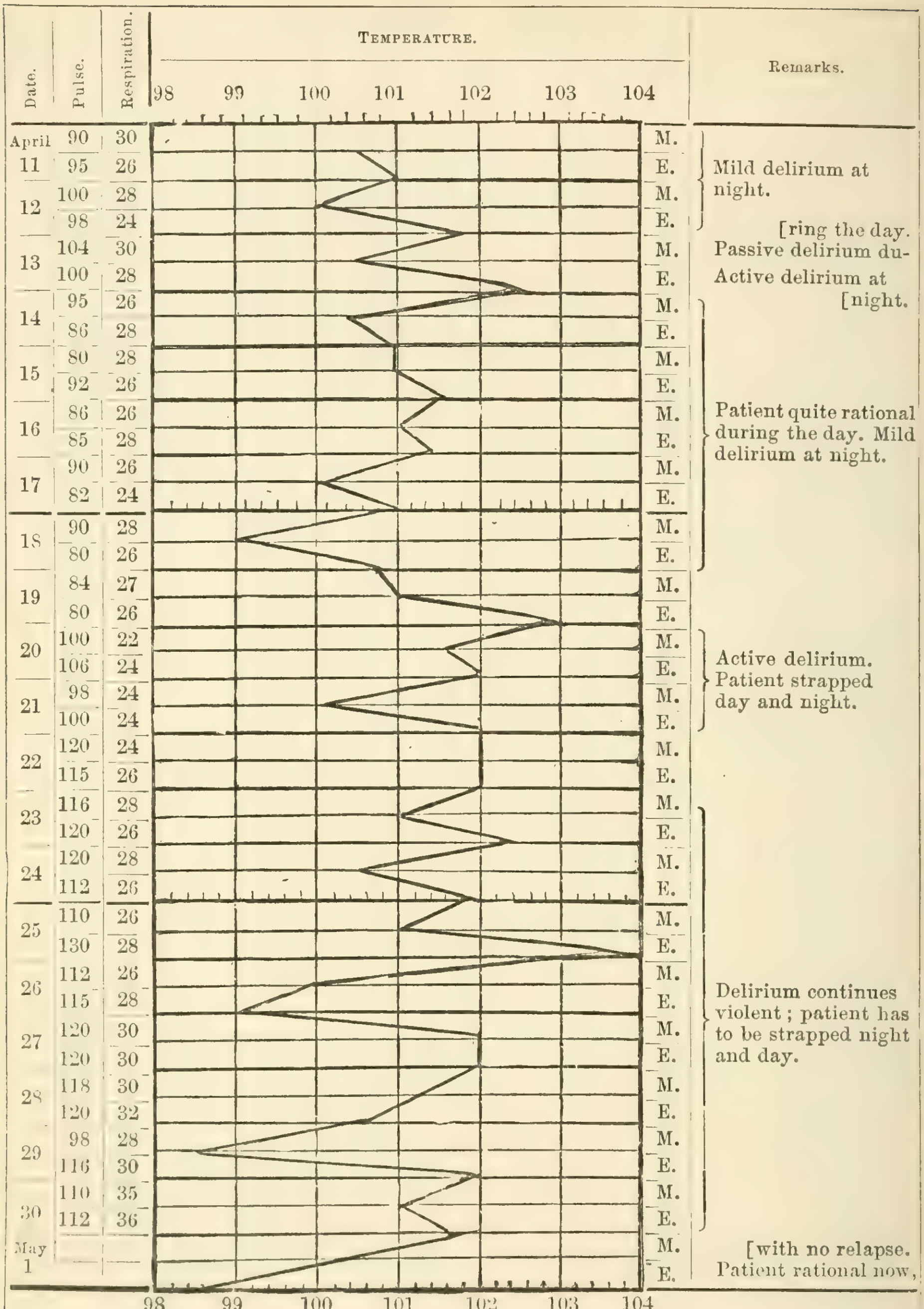
Fig. 34.



Temperature chart of S. R., aged 38. Delirium tremens following fracture of femur. Delirium appeared the first night after the patient's admission to the hospital. The treatment consisted in the administration of bromide of potassium and chloral hydrate. Recovery.

Diagnosis of Delirium Tremens.—From what has been said, it will be seen that the diagnosis of delirium tremens is generally easy, in spite of the misrepresentations which are made, and the absolute lies, as to habits, which are too apt to be told, both by the patient and his friends. Sometimes all are deceived in the matter, and the attack comes on as a surprise. The patient has only been a moderate drinker, and if the additional and depressing effects of an accident had not occurred, neither himself nor his friends would have even thought of him as a subject for the disease. Therefore, it is but justice to say that patients' statements, denying drinking habits to any harmful extent, may be given in perfectly good faith. The ideas of people differ so much as to what is harmful in this matter, that it is important for the surgeon to find out if possible what are really the facts of the case, both as to the amount and as to the kind of liquor used.

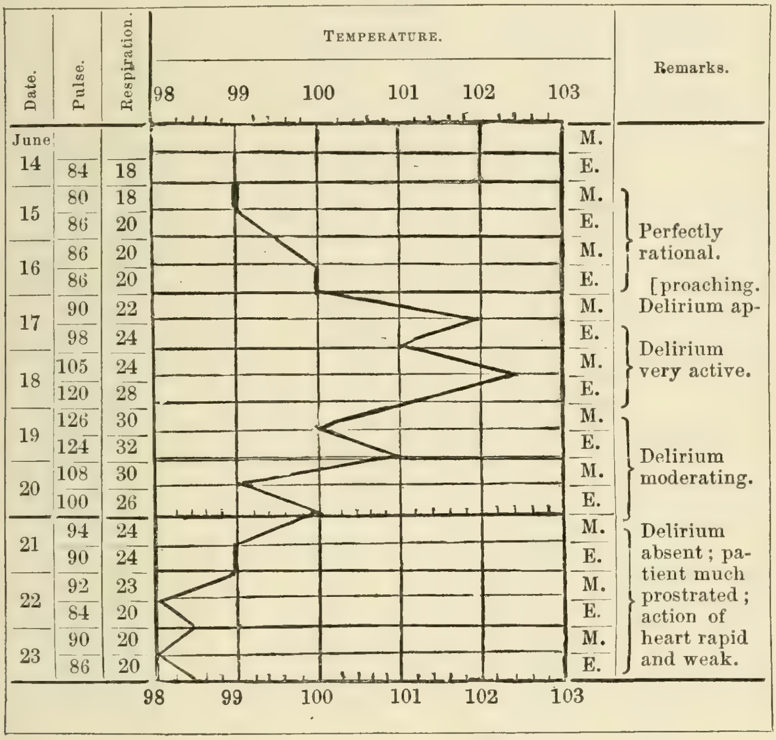
Fig. 35.



Temperature chart of W. H., aged 45, a moderate drinker. Delirium tremens following compound fracture of leg and fracture of ribs. The treatment consisted in the hypodermic use of morphia at night, with the internal administration of large doses of bromide of potassium and chloral hydrate. Recovery.

The peculiar tremors of delirium tremens are very characteristic; if I may so express it, they are loose and free, without spasmodic jerkings; somewhat jelly-like, and giving a general idea of instability. They seem to say "prop me up, prop me up; if you don't prop me up, I shall die."

Fig. 36.



Temperature chart of A. N., aged 50, a steady drinker but not an habitual drunkard. Delirium tremens following fracture of the patella. During the stage of delirium the patient was treated with morphia hypodermically (a quarter of a grain every six hours), and chloral (15 grains) and bromide of potassium (30 grains) every four hours, by the mouth. The diet consisted of liquid and concentrated food: beef-tea with capsicum, milk, soup, etc. Mechanical restraint was employed from June 17 to June 20. Recovery.

Treatment of Delirium Tremens.—The disease being one of depression, it is this "propping up" that is required in the treatment. Nourishment and sleep will bring most cases to a successful issue. Of course the nourishment must be digested, and the digestive organs may not at first be ready for their work. To those who are not too weak, an emetic may be given with most excellent effect. One of the best is mustard and water. Then the bowels may require attention, for often the patient has been very neglectful of himself in this respect. An enema, a large one, of soap and water, will mostly accomplish the object. This plan may look like reducing the patient. On the contrary, it is simply aiding to bring the digestive apparatus into a receptive state. There is no use in cramming down what will not be assimilated, and what will be almost certainly rejected. After the stomach has become somewhat retentive, we may begin with small amounts of hot and well-spiced beef-tea, or soup, repeated at short intervals. If milk can be taken, so much the better. As to medicines, opium, the bromide of potassium, chloral hydrate, the tincture of digitalis, and alcohol, are at the command of the surgeon.

At times the case is so urgent that these have to be resorted to at once, in order to procure sleep, and other indications may be met afterwards. It is in this state that the surgeon most frequently finds his delirium-tremens patients. Time often will not permit him to take risks. Then hypodermic injections of morphia should be given at once. In cases of fracture, the limb must be so guarded and bound up that it will move as one mass, and not be held by extending bands, or other means, to fixed places. Soft splints padded with cotton should be applied, and then the part may be bound up in a pillow. A suspension apparatus may also be useful. One has to be regardless of the accurate apposition of the fragments; that is to be attended to after quiet and sense have been restored. Where it is absolutely necessary, restraint by strapping the uninjured parts to the bed may have to be resorted to. Under all circumstances the patient must be most carefully watched, for in some way or other he will manage to disturb his dressings or to injure himself, if this be not done.

When sleep comes on, everything to encourage its continuance should be observed. When the patient wakes he is always much better, and often perfectly sane. Now is the time to push the nourishment, for it is the true reliance to bring about a permanent cure. The anodynes and stimulants are a weak prop, if food does not go with them. They may be gradually withdrawn, and may be again resorted to in full measure should relapse be threatened. It is not my intention in this article to discuss the relative therapeutic value of the different remedies for delirium tremens. The treatment must be based on the general principle that the disease is one of depression. Nourishment, withdrawal from exciting surroundings, and sleep, are what are wanting. Much may be done to ward off an attack if the surgeon is forewarned as to habits. Early measures to secure rest and sleep, under these circumstances, will often be entirely successful.

ANÆSTHETICS AND ANÆSTHESIA.

BY

HENRY M. LYMAN, A.M., M.D.,

PROFESSOR OF PHYSIOLOGY AND OF DISEASES OF THE NERVOUS SYSTEM IN THE RUSH MEDICAL COLLEGE, CHICAGO.

The term Anæsthesia, derived from α *privative*, and αἴσθησις sensation, is employed to signify a condition of the nervous system, resulting either from disease or from the administration of certain substances, by which the individual is rendered incapable of perceiving external impressions.

History of Anæsthesia.

From the earliest ages attempts have been made to relieve pain by the induction of insensibility. Homer records the use of cataplasms, which doubtless owed a portion of their anodyne efficacy to the products of fermentation which they contained. The Egyptians were acquainted with the soothing effects of *nepenthe*, a drug probably identical either with Indian hemp or with opium. Herodotus refers to a practice among the Scythians of inhaling the vapors of hemp for the purpose of intoxication. The Chinese were also accustomed, as early as the third century, to produce insensibility during surgical operations, by the use of Indian hemp. There is a tradition to the effect that, among the ancient Assyrians, the pain of circumcision was prevented by compression of the veins in the neck, during the time of operation. Pliny and Dioscorides relate that the Egyptians possessed a species of rock, brought from Memphis, which they were accustomed to apply in the form of a powder, moistened with sour wine, to painful wounds. This was probably a primitive method of producing local anæsthesia with carbonic acid gas. The most potent anæsthetic known to the ancients was the drug *mandragora*. Its infusion in wine was known to the Greeks by the name of *morion*. Apuleius states that half an ounce of this preparation would render one insensible even to the pain of an amputation. The sleep thus produced might continue for several hours; hence, no doubt, the origin of the story of the sleep of Juliet, as recorded by Shakespeare. The Jewish women were accustomed to give this anæsthetic wine to the victims of crucifixion; hence the record of the "wine mingled with myrrh," in the gospel of St. Mark.

The practice of inducing anæsthesia by inhalation, may be traced from the Scythians of the age of Herodotus, through the middle ages. While Dante was writing the Inferno, Theodoric, a surgeon of Bologna, taught the art of producing insensibility by inhalation of the vapor yielded by a medicated sponge that had been steeped in a decoction of opium, belladonna, hyoscyamus, mandragora, hemlock, ivy, and lettuce. It is probable that the

anæsthetic properties of ether and alcohol were known to the alchemists. Giambattista della Porta, in a volume on Natural Magic, described the preparation and administration of certain volatile substances which were to be kept hermetically sealed in leaden vessels, to preserve their virtues. The effects of their inhalation appear to have closely resembled those of ether. Albertus Magnus (A. D. 1193–1280) taught the art of distilling fire-water (*aqua ardens*) from red wine and common salt. May not this have produced a mixture of ether and alcohol capable of producing anæsthesia by inhalation? The closing years of the last century were marked by a remarkable apathy regarding the use of anæsthetics. With the exception of opiates, the majority of the drugs upon which the ancients relied had gone out of fashion. James Moore, in 1784, proposed to effect anæsthesia in surgical operations by compression of the principal nerves of the affected limb. John Hunter had observed the production of local anæsthesia by refrigeration of the tissues of animals, and Baron Larrey had remarked the same thing among his patients upon the icy field of Eylau. The newly discovered gaseous elements had attracted the attention of chemists, and the vapor of sulphuric ether had been inhaled by Dr. Pearson, of Birmingham, as early as 1785, but without practical results. In the year 1799 (April 9), Humphry Davy, then laboratory assistant of Dr. Beddoes, in the Pneumatic Institution at Clifton, near Bristol, discovered the exhilarating properties of nitrous oxide gas. Shortly afterwards, having inhaled the gas while suffering from the eruption of a wisdom tooth, he observed that the pain was relieved while under the influence of the gas. He recorded his experience, with the following comment: "As nitrous oxide, in its extensive operation, seems capable of destroying physical pain, it may probably be used with advantage in surgical operations in which no great effusion of blood takes place."

Though widely circulated, this paragraph seems to have produced no practical result until the Hartford dentist, Horace Wells, turned his attention to the subject in the year 1844. During this long period of time, no systematic research had been undertaken with a view to the discovery of a method for the production of artificial anæsthesia. The anæsthetic properties of sulphuric ether were, however, being gradually ascertained in an empirical way. In the year 1785, it had been employed by Dr. Pearson, in Birmingham, as an inhalation for the relief of spasmodic asthma. Dr. Warren, of Boston, had likewise used it, in 1805, for its anodyne effects in the later stages of consumption. In the year 1818, Michael Faraday published a brief notice of the anæsthetic properties of ether vapor, which he considered a dangerous substance. Experimental physiologists also became acquainted with its stupefying effect upon animals; and, in the year 1836, Christison recorded, in his work on Poisons, the case of a young man who had been rendered completely insensible by the vapor of ether. Among drug clerks and reckless young people, the practice of inhaling the vapor of ether was a favorite mode of dissipation in certain parts of the world. In the year 1839, a young negro was thus stupefied, to the great alarm of his companions, in the village of Anderson, South Carolina. This incident served to encourage Dr. Long, then residing in Jefferson, Georgia, to administer the vapor to a patient who was accustomed to the practice of inhaling ether. He was thus rendered insensible, and a tumor was removed without pain, March, 1842. Three or four other patients were anæsthetized with similar success during the years 1842 and 1843, but as the doctor resided in a remote and isolated portion of the country, and as he published no statement of his experience, his discovery remained unknown to the scientific world.

During the month of December, 1844, an itinerant lecturer on chemistry, named Colton, undertook to exhibit the exhilarating properties of laughing-

gas before a popular audience, in the city of Hartford, Connecticut. The dentist, Horace Wells, who was present, observed that the person to whom the gas had been administered seemed quite insensible to the pain of the bruises which he had sustained by reason of a fall while under the influence of the gas. He at once imagined that a tooth might be extracted without pain from a person whose sensibilities were thus temporarily obtunded. The very next day he performed the experiment upon himself, inhaling a quantity of the gas, which had been prepared by Dr. Colton. The success of this attempt was complete, and in a few weeks he had in like manner removed teeth from the mouths of a dozen different patients. Visiting Boston for the purpose of introducing his method in that city, he undertook to extract a tooth from a patient to whom the gas had been administered before the students of the Harvard Medical School. The experiment was unsatisfactory, as the patient uttered a cry at the moment of extraction, though he afterwards asserted that he had felt no pain. So great was his chagrin at this failure, that Dr. Wells ceased to interest himself in the subject of anæsthesia, and his death occurred not long afterwards (Jan. 14, 1848). Before this event, however, one of his former pupils, a young dentist in the city of Boston, William T. G. Morton by name, had made known the anæsthetic properties of the vapor of sulphuric ether. At the suggestion of a noted chemist, Dr. Charles T. Jackson, he had experimented with ether, inhaling its vapor until insensibility had been induced. This event occurred during the evening of September 30, 1846. On awaking from an artificial sleep which had endured for eight minutes, Dr. Morton resolved to administer the anæsthetic vapor to the first patient who would submit to its use. A man named Eben Frost presently applied for relief from an aching tooth, and was successfully kept under the influence of ether during the whole time of the extraction. It was at once perceived that this discovery might find a wider range of utility than could be afforded by the practice of dentistry, and on the 16th of October, 1846, Morton was invited to etherize a patient from whom Dr. J. C. Warren was about to remove a vascular tumor of the neck, at the Massachusetts General Hospital. The experiment was attended with such a degree of success that it was again and again repeated, until a number of capital operations had been thus performed with the most satisfactory results.

Intelligence of the great discovery reached England, December 17, 1846, and was speedily diffused throughout the civilized world. During the following year, the celebrated physiologist, Flourens, described the effects of chloroform upon the lower animals. A medical student in London, Furnell by name, about the same time accidentally discovered its anæsthetic properties by inhalation of its vapor, and at his suggestion it was several times employed in St. Bartholomew's Hospital by Sir William Lawrence and Mr. Holmes Coote. In the mean time a hint regarding this substance had reached Dr. J. Y. Simpson, of Edinburgh, and after testing the drug in his own person he administered it with the greatest freedom. On the 10th of November, 1847, he published the details of not less than fifty cases in which he had used chloroform with perfect success. The agreeable qualities of the new anæsthetic led to its speedy adoption in preference to ether. The occasional occurrence of death from its effects has caused much debate regarding the comparative dangers from the use of different anæsthetic agents, and the superior safety of ether has in England and in the United States produced a very important reaction in favor of the original agent introduced by Morton. Germany and the greater portion of France still prefer chloroform, a substance which by its energy, its concentration, and its agreeable effects, will always commend itself to those who are inclined to place vigor and precision before safety. Many other substances have been experimentally tested as

anæsthetic agents, but the majority of them are either too dangerous or too costly to admit of general use.

Phenomena of Anæsthesia.

Certain minor peculiarities characterize the anæsthetic effects produced by inhalation of the different anæsthetic gases and vapors. The principal phenomena, however, are common to all. A description of the symptoms occasioned by the inhalation of the vapor of ether or of chloroform, will convey a sufficiently accurate idea of the manner in which artificial anæsthesia ordinarily supervenes.

The first effect of the inhalation of an ethereal vapor is a local excitement of the nervous apparatus of the respiratory passages. The senses of taste and smell, and the naso-pharyngeal branches of the fifth pair of nerves, are powerfully excited. The activity of the salivary glands is aroused, and acts of deglutition are stimulated. Sometimes a disagreeable tickling is experienced in the larynx, and the patient coughs. A sense of suffocation may be experienced, and the patient assumes an attitude of resistance, struggling to free himself from the inhaler. Animals, confined in a retentive apparatus, often endeavor to prevent the entrance of the anæsthetic vapor by restricting their movements of respiration within the narrowest possible limits.

These first effects of local contact are soon succeeded by the more extensive results of general saturation of the tissues with the stupefying agent. The vapor rapidly passes into the blood, and is conveyed to every living element of the body. The initial effect is disturbance of function; the subsequent effect is paralysis of function. Disturbance usually assumes the form of exaltation; it is also always marked by perversion of the normal intensity of physiological sequences. The special senses give evidence of this agitation. There is a humming sound in the ears, and subjective impressions of light flash in varying forms across the visual field. The pulsation of the heart can be felt, and the vermicular movements of the intestines can sometimes be perceived. The arteries throb, the brain seethes, waves of heat flush the surface of the body, perspiration appears upon the face, and may become general, the pulse rises, respiration is accelerated, the pupils contract, the eyes close, reflex irritability is exalted, and in his general appearance the patient resembles a person in the earlier stages of alcoholic intoxication. To this period of excitement succeeds the stage of diminishing function. The cutaneous sensibility grows less, the temperature falls, the pulse recedes towards the normal standard, the blood pressure diminishes, the respiratory movements become deep and full, like those in profound sleep, voluntary movements cease, consciousness gradually fails, reflex movements are abolished, and the patient becomes utterly insensible. If the act of inhalation be urged beyond this point, syncope may occur, and a cessation of respiration and circulation may terminate the life of the patient.

During the act of inhalation the *eyes* are generally closed. The eyelids often move as if winking. At first, the pupils are variable in their diameter. When anæsthesia is fully declared, the pupils are contracted; but if the condition of stupefaction is carried to an extreme, dilatation takes place, and persists till death. During the period of complete insensibility, the eyeballs are frequently turned upwards and inwards, sometimes assuming the position of conjugated deviation. *General sensibility* is disturbed at a very early stage of the anæsthetic process. After the brief period of initial exaltation, cutaneous sensibility diminishes at a rapid rate. This diminution is first manifested upon the least sensible portions of the surface. Sensibility persists

longest upon the anterior surfaces of the trunk, about the eyes, at the tips of the fingers and toes, and especially in the neighborhood of the anus and the organs of generation. The initial effects of inhalation are manifested in the *brain* by a great exaltation of the powers of perception and reasoning. Ideas are quickened, but, with a diminution of the powers of sensation, the sphere of vivid perception is correspondingly narrowed. Consciousness remains perfect as long as it exists, but its field progressively contracts to a vanishing point, around which seems to gather an atmosphere of half formed and ever fainter perceptions. The powers of attention, memory, reasoning, judgment, and volition, can be exercised with perfect precision as long as the formation of ideas persists, but the progressive movement towards severance of the brain from all contact with the external world through the medium of the senses, becomes at length so complete that consciousness can deal only with ideas which originate within the brain itself. In this condition the patient seems to dream, and the memory of these dreams may be preserved after awakening. Sometimes all avenues of communication with the external world may be closed but one—usually the sense of hearing—and the patient experiences a feeling as if separated from his body; as if occupying the position of an impassive spectator of the scene in which his material organization forms a constituent part. In such cases volition has ceased; perception, memory, imagination and consciousness, alone remain. But, as the anæsthetic process advances, these functions also lapse into the potential state, and the patient passes into a condition of vegetative existence.

The effects of anæsthetics upon the powers of *volition* are somewhat variable. Children and adults of an impressible temperament are more easily overcome than patients of a vigorous, intellectual character. By an effort of the will, the progress of anæsthesia may be delayed, and a mind trained in habits of introspection and analysis will retain consciousness longer than if less happily organized. A similar phenomenon is often remarked during the progress towards alcoholic intoxication, when a sudden and powerful act of volition, exercised, perhaps, as the result of some unexpected stimulus from without, serves to restore the condition of sobriety. By such effort, and even without apparent effort, perfect intelligence may often be maintained for a considerable period after the loss of the power of perceiving painful sensations. The patient may be conscious, intelligent, and capable of conversation, yet almost wholly insensible to pain; and, on recovery, quite oblivious of the passage of time, and of the majority of the events that have transpired.

During the initial stage of anæsthesia, the power of *muscular movement* is usually exaggerated. Such voluntary movements as may be put forth, are performed with unwonted vigor and celerity. The patient may raise his hand or move his foot without willing the act, yet with perfect knowledge of what is done. The involuntary muscles exhibit the general disturbance with the greatest uniformity. The heart beats more rapidly, and sometimes more violently; the temples throb; the movements of respiration are accelerated. Sometimes cough will be excited, the patient vomits, the bladder and the rectum may be evacuated. Convulsive phenomena sometimes appear. They may be limited to insignificant fibrillary twitchings of the facial muscles, or the patient may be shaken as if in an ague-fit. Epileptic patients may be roused by the anæsthetic to the manifestation of a complete convulsion, from which they will pass into a condition of the most profound insensibility—a combination of coma and anæsthesia. Sometimes the convulsive movement assumes the tonic form. This is said to be more frequently witnessed as a result of chloroform than of ether. An arm or a leg, one half of the body, or even the entire frame, may become perfectly rigid as if fixed in a tetanic

spasm. Such conditions indicate a profound and dangerous implication of the most important nervous centres.

As the process of stupefaction advances, *reflex action* diminishes, the power of voluntary movement ceases, and the patient enters upon a condition of perfect repose, in which the only movements that persist are those which sustain the functions of respiration, circulation, and unconscious life. By careful administration of the anæsthetic this condition may be maintained without danger for a considerable period of time.

The *respiratory movements* are accelerated, even before the commencement of inhalation, when the patient is agitated by nervous apprehensions. Ether tends to quicken respiration during the early and middle stages of inhalation, and to depress its rate slightly below the normal when the stage of insensibility has been reached. Chloroform tranquillizes the initial agitation at an earlier stage of the process, and produces the same final result during the period of unconsciousness. Causes dependent upon the age, sex, temperament, and previous life of the individual, disturb the general course of respiration to such a degree that it is almost impossible to include all cases in a general description. Sometimes the respiratory movements succeed each other with the utmost irregularity, and may even be suspended altogether for a considerable time. Such patients are said to be intolerant of the anæsthetic, and are liable to pass into a condition bordering on the convulsive state. In certain cases, the patient, though quite conscious and capable of intelligent utterance, seems to have forgotten to breathe. From this condition he may be aroused by the voice of the surgeon, or by a sudden pressure upon the thorax or abdomen. During the stage of general muscular relaxation, respiration becomes deep and regular, being less frequent but more profound than during the waking state. The exhalation of carbonic acid gas is increased during the period of excitement, and it is diminished during the period of tranquil anæsthesia.

The action of the *heart* corresponds closely with the conditions of respiration. During the occurrence of tetaniform rigidity, the pulse may become almost imperceptible. When respiration is slow and feeble, the heart beats in a faint and sluggish way. Again, it may suddenly start off at a very rapid rate, only to sink suddenly into a condition approaching syncope. Such inordinate fluctuations and rapid variations should excite grave apprehensions for the safety of the patient. In the normal course of inhalation, the pulse at first is small and frequent, increasing its rate as respiration becomes accelerated, until the stage of muscular resolution is approached, when it begins to recede. With the approach of this stage the arterial coats relax, and the pulse grows soft. When complete unconsciousness supervenes, the volume of the pulse is considerably enlarged, and its rate may fall below the normal standard. As the pulse falls, the general circulation improves. Turgid veins subside; the cutaneous vessels resume their normal calibre. The face may even become pale, and the mucous surfaces exchange their lively color for a fainter tinge. Extreme pallor, or a dusky hue, should be viewed with alarm.

The *temperature* of the body is generally diminished during the time of anæsthesia. At first, the temperature of the surface is elevated by reason of the increased afflux of blood; but as inhalation progresses the liberation of heat diminishes, and the temperature of the body exhibits a considerable fall. This becomes more notable when the more energetic anæsthetic substances are employed.

The function of *secretion* is at first augmented, and finally diminished by the action of anæsthetics. The degree of augmentation depends considerably upon the character of the anæsthetic that is employed.

The time during which anæsthesia may persist after the cessation of inhalation, is quite variable, being dependent upon the volatility of the agent. It is usually three or four minutes after the use of ether, and a little longer after that of chloroform. Recovery is almost immediate after the employment of nitrous oxide or ethyl bromide. When the patient has been made insensible, the condition of anæsthesia may be indefinitely maintained by the continuous administration of relatively small quantities of the drug. A condition in which the patient continues to moan and to cry, perhaps even resuming a feeble struggle with the attendants, is an evidence that the anæsthetic is either not properly inhaled, or that the individual is in a situation not wholly free from danger. Careful administration will generally overcome the difficulty, but certain patients are especially refractory. Drunkards, by reason of long established tolerance of the anæsthetic effects of alcohol, require large and sometimes dangerous quantities of ordinary anæsthetics to effect resolution and insensibility. Mental agitation may produce a temporary tolerance. Operations about the anus and genitalia generally require an unusual quantity of anæsthetic vapor for the production of complete anæsthesia.

The phenomena of recovery ordinarily consist in a regular inversion of the manifestations which have marked the process of induction. If the patient has been previously exhausted by any cause, the period of recovery may be greatly prolonged, and symptoms of prostration may appear. After a long and difficult operation, it may be difficult to distinguish between the effects of shock and those of the anæsthetic. Brief operations, on the contrary, seem to produce less depression when the element of pain is abolished.

Physiology of Anæsthesia.

The action of anæsthetic substances is exerted through the blood upon the nervous system. They operate by contact, rather than by chemical union or decomposition. This mode of action is exhibited by many of them in connection with non-vital processes of a chemical character. A taper will be extinguished in a jar containing one part of carbonic anhydride mixed with seven parts of oxygen, just as readily as in an atmosphere deprived of oxygen. The anhydride effects an arrest of the process of oxidation by its mere presence, without in any way taking the place of either oxygen or oxidizable substance. In like manner, the luminous oxidation of hydrogen phosphide may be arrested by the presence of a very small quantity of the vapor of ether, or turpentine, or naphtha. The luminous glow that is visible around a stick of phosphorus in a darkened room, will at once disappear if a drop of ether or chloroform be introduced into the container. As the ethereal vapor is dissipated by evaporation, oxidation begins again, and the phosphorus glows once more as perfectly as at first. Upon the more complicated processes of vegetable life, these substances exert a similar inhibitory influence. The addition of ether to an infusion containing yeast, at once arrests the process of fermentation. On removal of the anæsthetic, by evaporation or by filtration, the activity of the yeast fungus is renewed, and fermentation is again resumed. If an aquatic plant be placed in a watery solution of ether or chloroform, its absorption of carbonic anhydride and its exhalation of oxygen cease. The plant does not die; it merely sleeps. On replacing it in pure water, its natural respiration is immediately resumed. The germination of seeds may also in a similar manner be arrested by surrounding them with an anæsthetic atmosphere. The irritability of the protoplasm in the cells at the base of the petiole, in the leaf of the sensitive plant, is in like manner

inhibited by anæsthetic vapors. A vigorous specimen of this species, placed for half an hour under a bell-glass with a sponge saturated with ether, will no longer exhibit any irritability. Its healthy appearance remains unchanged, but it no longer absorbs carbonic anhydride, and its leaflets will not shrink when touched. Restoration of the plant to a pure atmosphere is soon followed by complete recovery of all its natural functions.

Each one of these experiments illustrates the tendency to inhibition of certain molecular movements in the presence of an anæsthetic substance. All molecular movement is not thus arrested. Alcoholic fermentation ceases in a solution of ether, which still permits the transformation of cane-sugar into grape-sugar. It is at present impossible to describe the essential nature of the inhibitory process. The only thing beyond dispute is the fact that anæsthetic substances tend to restrict the ordinary freedom of chemical exchanges in living matter. In the animal body, while all parts are thus modified by the anæsthetic, certain tissues are more than others affected by its presence. To this fact is due the progressive character of artificial anæsthesia. The more highly differentiated the tissues of an animal, the more evidently successive and complex the phenomena of anæsthesia. Consequently it is in the higher animals, with an elaborate nervous apparatus, that these phenomena are most conspicuous.

The action of anæsthetic vapors and liquids is exerted through the medium of the circulating fluids of the body upon the cellular units of which it is composed. Introduced into the blood by passage through the walls of the pulmonary air-cells, absorbed by the surfaces of the alimentary canal, or conveyed directly into the current of the blood by intra-venous injection, it is only when the nervous elements have been reached that the anæsthetic process begins. Primarily local in its action, the effect of the anæsthetic becomes generalized when the central nervous organs are invaded. Numerous experiments have thus shown that the local action of chloroform upon the substance of the spinal cord is sufficient to abolish peripheral sensation and muscular movements, even though the peripheral organs have been sheltered from its action. In like manner, the functions of the brain having been abolished, all those peripheral functions which depend upon the integrity of the cerebrum are, for the time being, incapable of performance. When freely circulated through all parts of the body, the anæsthetic produces local effects throughout the whole mass of the body, but the consequences of its action upon the principal nervous centres are the most conspicuous of the resulting phenomena.

The condition of artificial anæsthesia presents many points of resemblance to natural sleep, but there are also certain important points of difference. The advent of normal sleep is heralded by a gradual failure of the special senses. The eyes close, general sensibility fails, and, finally, the sense of hearing is abolished. In the locomotive apparatus, the voluntary muscles of the limbs are the first to yield; then follow the muscles of the trunk. The power of reflex movement is not abolished. Respiration and circulation continue, though with a slightly diminished rate. As sleep invades the brain, perception of the external world is gradually diminished by the failure of the external senses. But this arrest of communication does not at once prevent the development of ideas within the brain. Certain groups of cortical cells may remain active after the establishment of sleep in certain other groups. Deprived of that guidance which is derived from the impressions of sense, the attention of the waking portions of the brain is attracted to such impressions of internal origin as may arise in the territories of the pneumogastric and sympathetic nerves. Hence a succession of erratic ideas, attended with varying degrees of consciousness, dependent upon the degree of uniformity in

the condition of the cortical portion of the brain. Or disturbing causes may be originated in the cerebral centres themselves. Groups of cells which have acquired an excessive or morbid irritability, may still continue to perform a certain amount of functional work as a consequence of previous impressions that have not yet been effaced, and this work will produce results in the field of consciousness. But, through lack of a simultaneous production in consciousness, of that vast complex of associated perceptions and conceptions which is occasioned by the coördinated activity of all parts of the brain during the waking state, this isolated cell-work excites only imperfect trains of thought, which must necessarily progress after a very imperfectly ordered fashion. Such processes constitute what is called a dream. When the special function of the cortical cells is rapidly, uniformly, and completely arrested, sleep is profound and dreamless. The development of this condition is accompanied by a comparatively anæmic condition of the cerebral substance. This comparative anæmia is the result, rather than the cause, of sleep. It is effected by the intervention of the nerves which regulate the supply of blood for every organ, in strict accordance with the degree of its functional activity.

Quite unlike the advent of natural sleep is the stormy introduction to the sleep of artificial anæsthesia. This is due to the fact that the anæsthetic sleep is produced by the action of a foreign substance of a paralyzing nature, to which the tissues are wholly unadjusted. The initial effects of contact with such a substance, are contraction of irritable protoplasm, liberation of motion, phenomena of excitement. This produces an increased circulation of blood, and all the functions of the nervous system are momentarily exalted by the combined action of increased blood-supply and local irritation of nervous matter. But the conspicuous and characteristic phenomena of anæsthesia are caused by the paralyzing energy of the anæsthetic. At first the vascular walls contract, as a consequence of their local irritation by the medicated blood. But, almost immediately, they begin to relax under the paralyzing influence of the drug, and an increased supply of blood reaches the muscular and nervous substance of the heart. This organ contracts more vigorously, and propels through the dilating bloodvessels a larger amount of blood, to stimulate the brain, the spinal cord, and every portion of the body. A general though temporary increase of function is the result. Muscular movement and reflex action are exaggerated. The sensory apparatus is in like manner rendered more efficient. Painful sensations may thus be briefly intensified by the means that are employed for their abolition. But this stage of excitement is soon passed. Transported by the blood, the anæsthetic soon pervades the higher nervous ganglia, and depresses their activity. The action of the heart is thus retarded, and the pulse recedes. In like manner the movements of respiration are again brought down to the normal rate, or even below it. The circle of the intellectual functions is progressively narrowed by the progressive paralysis of the cortical cells, and the connection of ideas is disturbed by the increasing disconnection of the centres in which they arise. Complete paralysis of these organs is followed by loss of consciousness and anæsthesia. If, now, an equilibrium be established between the introduction and the elimination of the stupefying vapor, the anæsthetic process may be continuously sustained. But if its introduction be urged beyond the power of the tissues to free themselves, they become supersaturated, and systemic death is the final result.

Reasoning from analogy, it has been suggested that anæsthetic substances modify nervous tissue by a sort of coagulation of its protoplasm. But coagulation is incompatible with life. Keeping in mind the fact that the effect of anæsthetic substances is temporary, it seems more probable that they operate by inhibition of those chemical processes which are associated with the libe-

ration and diffusion of motion throughout the system. Among the protoplasmic molecules, the substance acts the part of a screen, like a cloud between the sun and the earth, hindering the energies of one from acting upon the susceptible matter of the other. Too frequent repetition of this action, however, eventuates in the production of certain permanent modifications in the constitution of living matter. These are best illustrated by reference to the permanent alterations of nervous tissue which are produced by the immoderate use of alcoholic anæsthetics.

Mode of Administering Anæsthetics.

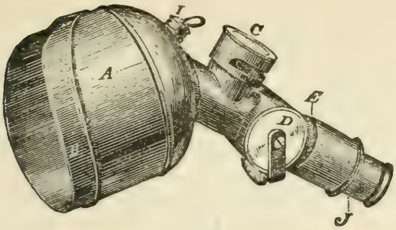
The patient should occupy a recumbent position in order to facilitate the circulation of blood between the heart and the brain. Clothing should be adjusted in a way to permit the freest respiratory movements. The anæsthetic substance may ordinarily be inhaled as it evaporates from a napkin placed over the mouth and nostrils. Innumerable forms of more or less complicated apparatus have been contrived for the administration of graduated quantities of anæsthetic vapor; but the majority of these inhalers are dirty, cumbrous, disappointing, and unsafe. For ordinary use nothing has yet been found better than the simple napkin or its equivalent. For the administration of nitrous oxide gas, a special form of inhaling apparatus is necessary, since it is important that all air be excluded during the act of inhalation. (Figs. 37, 38.) A very ingenious and useful inhaler has been contrived by Mr. Clover, an English surgeon of large experience with anæsthetics, for either the successive or the simultaneous inhalation of nitrous oxide gas and ether vapor. (Fig. 39.) With these exceptions, the simplest means of introducing the anæsthetic vapor into the lungs are always the best. During the whole time of inhalation, the condition of the patient should be continually observed by an experienced physician, and the earliest symptoms of danger should be immediately noted and opposed by vigorous treatment.[1]

Accidents of Anæsthesia.

In certain rare cases, death may occur *suddenly* during the act of tranquil inhalation. The movements of the heart and of the respiratory organs seem to be almost instantaneously arrested; this accident seldom occurs unless the patient has been greatly enfeebled by previous disease or by hemorrhage. Death by *asphyxia* may occur during the act of inhalation. This accident might be occasioned by the use of a badly-adjusted inhaling apparatus, or by suffocation with numerous wet napkins crowded upon the face; but this must be an exceedingly unusual event. It is when the trachea has been mechanically obstructed by the entrance of blood from a wound, or by the intrusion of fragments vomited from the stomach, that asphyxia is beyond doubt the cause of death. Asphyxia may occasionally be produced by the induction of tonic convulsion of the respiratory muscles, as a reflex consequence of the local irritant action of chloroform vapor when brought in contact with the laryngeal mucous surfaces. Ordinarily, however, the consequences of such local irritation are confined to the production of a tumultuous cough. More frequently the intervention of danger manifests itself by prolongation of the stage of excitement. The muscles may finally pass into a condition of rigid-

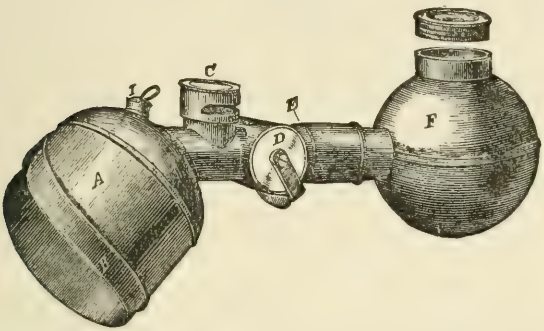
[1] [Further remarks upon the administration of special anæsthetics will be found under the head of the different agents employed. See pp. 424 *et seq.*]

Fig. 37.



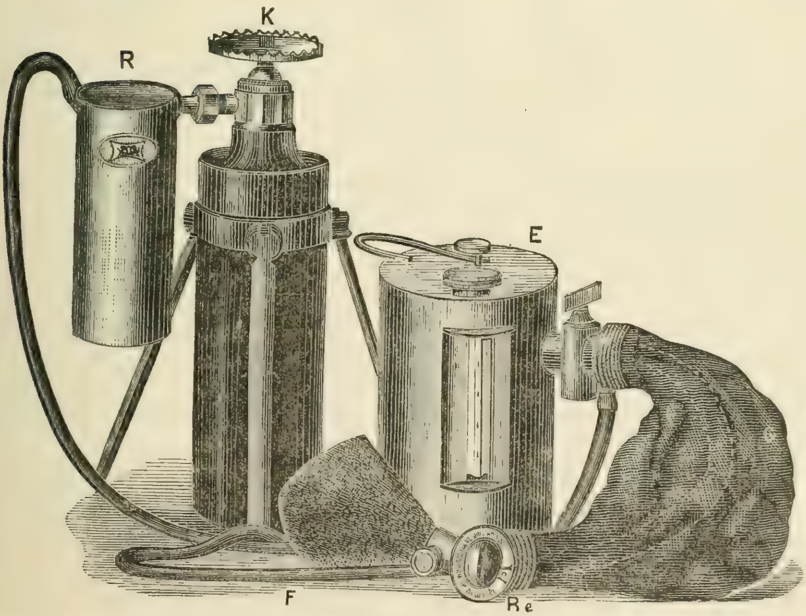
Codman and Shurtleff's inhaler for nitrous oxide gas. *A*, metallic hood; *B*, flexible rubber hood; *C*, exhaling valve; *D*, two-way stop-cock; *E*, sliding-joint; *J*, inhaling valve.

Fig. 38



The same apparatus adapted for the inhalation of ether. *F*, ether reservoir.

Fig. 39.



Clover's apparatus for inhalation of nitrous oxide gas and ether. *E*, ether reservoir; *F*, face-piece; *G*, caoutchouc bag for mixture of vapors; *R K*, nitrous oxide reservoir; *Re*, regulator.

ity, during which the pulse suddenly disappears, respiration ceases, and death occurs. Death in all such cases, and they form the vast majority of the examples of death during the anæsthetic process, is the direct result of the toxic effects of the drug upon the *nervous centres* which preside over the acts of circulation and respiration. It is, therefore, impossible to employ any anæsthetic agent without, in some small degree, at least, approaching the confines of danger. All diseases which diminish the energy of the heart and of the lungs, tend to increase the dangers of anæsthesia. Hemorrhage, intemperance, cold, hunger, want, misery, mental anxiety, loss of sleep, fatigue, are all causes of danger, because they serve to depress the vital energies. Since suffocation by the passage of food into the trachea has occurred during the act of vomiting excited by the anæsthetic, it is advisable to administer the vapor at a time when the stomach is probably empty.

The *rate of inhalation* may become a source of danger. Hasty saturation of the tissues with a powerful anæsthetic may cause speedy death. The primary stage of anæsthesia is a period of excitement, during which it is not impossible that fatal syncope may result from over-stimulation of the cardiac inhibitory apparatus before the fully toxic action of the drug has been displayed. Convulsions may thus be aroused, and may produce death by arrest of respiration, or they may be the forerunners of fatal syncope. Sudden excitement of the reflex apparatus, by incision of the skin before complete abolition of sensibility, may in like manner become a cause of death. It is for this reason always best to produce complete insensibility before the commencement of an operation, even though a certain slight risk of over-saturation of the tissues be thus incurred.

As a general fact, *children* are remarkably tolerant of anæsthesia. The rapid rate of circulation and respiration, and the larger relative surfaces of their bodies, provide for a speedy elimination of the anæsthetic substance, so that cumulative effects are almost out of the question. *Aged persons*, also, have been claimed as more than ordinarily favorable subjects for artificial anæsthesia. Few old people, however, become the objects of such experiment, and the fatality among them must therefore seem to be less than among the middle-aged who form the mass of patients. To such elderly patients, anæsthetics should be administered with more than ordinary care, for with them the phenomena of anæsthesia are liable to assume an adynamic character. *Women* resemble children in the rapidity with which they yield to inhalation. It has been thought that they are less liable than men to the accident of syncope during anæsthesia. At the menstrual epoch they are more than usually liable to nervous excitement and to hallucinations, but are otherwise not excessively exposed to danger. During the period of pregnancy, aside from the risk of injury through violent muscular efforts in the stage of excitement, there seems to be no unusual risk from artificial anæsthesia. The act of parturition seems to confer almost absolute immunity from danger through anæsthetic inhalation. Peculiarities of *temperament* and *constitution* appear to exercise no appreciable effect upon the course of anæsthesia. A predisposition to syncope does indeed furnish a contra-indication to the use of anæsthetics.

Various diseases of the *brain* and *spinal cord*, especially such as encroach upon the medulla oblongata and its neighborhood, increase the danger of accident. Epileptics are very liable to convulsion during the stage of excitement, but the immediately subsequent stage of resolution is sufficiently favorable to warrant the administration of anæsthetics to such patients. The same thing is true of hystero-epilepsy. Alcoholic intoxication and delirium tremens prohibit inhalation, because of the existing tendency to death from exhaustion and syncope. Surgical shock, for the same reason, constitutes a

condition unfavorable to the employment of anæsthetics. Gunshot wounds seem to form an exception to this rule, probably because of the great nervous exaltation which usually precedes their infliction. All forms of *pulmonary* and *intrathoracic disease* add to the risks of artificial anæsthesia, not through any increased liability to asphyxia, but by reason of the greater probability of the occurrence of syncope. For the same reason, organic diseases of the heart or the larger bloodvessels, overloading of the heart with fat, and fatty degeneration of its muscular structure, should preclude the use of anæsthetics. A slow, irregular, and feeble pulse, associated with precordial pain, difficult respiration, general lassitude, and evidences of degeneration in tissues accessible to observation, should excite suspicion of this form of morbid change. The violent palpitations of anæmia should exclude the more potent anæsthetics.

A condition of *excitement* and *terror*, preceding the act of inhalation, may increase the risks to which the individual is subjected. A certain amount of encouragement and reassurance of the timid patient, together with repeated stimulant doses of alcohol, should always precede the exhibition of the anæsthetic in such neurasthenic cases.

The risk of accident varies greatly in accordance with the nature of the substance selected for the production of insensibility. It should, however, always be remembered that no anæsthetic agent is absolutely free from risk. Every patient should, therefore, be made an object of special study before the commencement of inhalation, and all possible contra-indications should be fully considered.

Treatment of the Accidents of Anæsthesia.—Irritation of the respiratory passages caused by inhalation of anæsthetic vapor, soon subsides after the occurrence of complete anæsthesia, or after removal of the cause. If it persists, the purity of the substance should be determined. Vomiting not unfrequently occurs, especially if food has been recently taken. It is, therefore, expedient to defer inhalation for three or four hours after a meal. The sensation of suffocation which often oppresses the patient during the earlier stages of inhalation, may be relieved by larger dilution of the vapor with air. If the anæsthetic is given upon a napkin, the cloth should be raised from the face for a few seconds. Tolerance of the vapor will soon be established, and inhalation may then be rapidly conducted.

The principal dangers during inhalation are the arrest of respiration, and the cessation of cardiac movement. As a general thing, if *respiration* can be sustained the heart will continue to act. It is, therefore, important, whenever alarming symptoms appear, to guard the breathing—even to the extent of producing artificial respiration. This may be effected, preferably, by the methods of Sylvester or of Howard. The tongue may be drawn forward, not because the glottis can be thus opened, but for the sake of the reflex actions of respiration which may be excited. Faradaic stimulation of the thoracic surface may also be attempted. A powerful current should, however, be avoided; and the application should be restricted to the right side of the body, in order to escape the risk of arresting the movement of the heart by the passage of electricity through the enfeebled organ. For the use of electricity, the best method consists in placing one electrode over the track of the right phrenic nerve, in the neck, while the other electrode is applied to the wall of the thorax over the sixth intercostal space on the right side of the body. Electrical stimulation should be associated with the attempt to produce artificial respiration by Howard's method—the electrical circuit being completed during the elevation of the ribs, and interrupted during the time of their descent. Insufflation has been recommended as a means of filling the

lungs with air; but if performed in the ordinary way, it is likely to distend the stomach rather than the lungs. If a flexible tube be passed through the glottis into the trachea, or, more easily, through a tracheal opening, the lungs may then be easily filled with air. But such manœuvres consume valuable time. Complete inversion of the body, so that the head shall be thoroughly depressed, affords the most speedy and, certainly, one of the surest means of relief when cardiac *syncope* is exhibited. Tested in the physiological laboratory upon the lower animals, in whom chloroform had produced apparent death, this method of resuscitation has in numerous cases yielded very conspicuous results. Unfortunately, however, the energy of certain anæsthetic substances is so great that no degree of vigilance can obviate danger, nor can the most scientific methods of relief always effect a restoration when the patient has ceased to breathe. The only real approach to safety, the only irreproachable course of action, lies in complete abstinence from these potent drugs. The administration of atropine previous to the commencement of inhalation has been recommended with a view to protection against syncope by its stimulant effect upon the heart. Though it be a fact that the drug serves to accelerate the cardiac contractions, it certainly has a paralyzing effect upon the pneumogastric nerve connections of the heart; so that, while it may theoretically protect that organ from violent inhibitory shocks transmitted through the *vagi*, it is doubtful whether, in medicinal doses, it can effect any benefit greater than may result from the action of the anæsthetic itself.

Employment of Anæsthetics.

Artificial Anæsthesia in Surgery.—Briefly, it may be assumed that every painful and long-continued operation, upon a patient who presents none of the contra-indications already considered, constitutes an occasion for the induction of artificial anæsthesia. By the aid thus procured, many operations in surgery are rendered feasible which otherwise could rarely be proposed. It has, moreover, been asserted that by the use of anæsthetics the mortality after surgical operations has been considerably reduced. Without undertaking the discussion of a question into which numerous other elements must in fairness be admitted, it may safely be conceded that the removal of that dread of pain which was always so formidable an obstacle to early operation for the relief of disease, and the diminution of the danger of exhaustion by pain during the time of operation, have largely contributed to an increase of safety in surgery. It should not be forgotten, however, that loss of blood may be favored by the action of anæsthetics. The depressing effect of the more powerful anæsthetic substances may sometimes exercise a prejudicial effect upon the convalescence of exceptional individuals. Death may occur during the act of inhalation. But, notwithstanding all these possibilities, it can scarcely be doubted that the sum of human misery has been considerably reduced by the employment of anæsthetics in surgery.

Artificial Anæsthesia in Obstetrics.—The employment of ether for the relief of the pains of child-birth soon followed its introduction in surgery. Sir J. Y. Simpson became at once a most enthusiastic advocate of the new method, which soon became naturalized throughout the greater part of the civilized world. Objections to the practice have been raised on the ground of interference with a natural process. It may be conceded that in all truly natural labors the use of anæsthetics is superfluous; but, since the abnormal conditions of a partial civilization have introduced so large an element of pain into a naturally laborious, but not necessarily painful, process, the employment of

artificial means of relief is thoroughly justified. Painful parturition is as proper a subject for relief as painful menstruation. The proper stage of labor for the use of anæsthetics may be allowed to depend upon the degree of pain by which it is characterized. Inhalation may be employed during any stage of confinement. It is, however, desirable to avoid the induction of profound insensibility during the earlier portion of a labor which may be prolonged for many hours. A parsimonious use of the drug should be the rule, in fact, during the whole course of parturition, unless instrumental interference become necessary for the purpose of completing the delivery. For the production of anæsthesia, any one of the numerous substances used for this purpose may be employed; but the obstetrical anæsthetic *par excellence* is chloroform. Its convenience, its agreeable properties, and the remarkable degree of safety which has attended its exhibition under such circumstances, have all combined to give it the preference before all other anæsthetics. For the graver operations of midwifery, however, when complete insensibility is desired, sulphuric ether should be used.

When administered for the purpose of mitigating the severity of painful uterine efforts, it is not necessary to reduce the patient to a condition of silent insensibility. A few drops of chloroform vaporized from a handkerchief, and inhaled at the commencement of each pain, are usually sufficient. Thus employed, it is no unusual thing to hear a woman declare, at the close of a tedious labor, during which her complaints have been most volubly uttered, that the whole period has not seemed longer than fifteen minutes. By this intermittent method of inhalation, the stimulant effect of the drug is maintained. If complete insensibility be induced during the expulsive stages of labor, it may happen that muscular contraction is diminished, or even completely arrested. This is the consequence of over-saturation of the reflex spinal centres with the anæsthetic. The voluntary muscles are the first to yield; then follow the muscles which are employed in semi-voluntary expulsive acts; finally, the purely involuntary muscular fibres of the uterus. Excepting only cases of operative interference, it is desirable that during the concluding efforts of parturition the patient should sufficiently possess her senses to assist the involuntary uterine efforts by those powerful voluntary exertions which are most efficient in a state of consciousness. If, however, the sufferings of the patient combine with the effects of partial anæsthesia to render her uncontrollable, it is better to produce complete insensibility at the moment of delivery. With the birth of the child, inhalation should cease, unless some unusual operative interference should be required. The patient soon recovers consciousness, and ordinarily suffers very little pain or discomfort during the succeeding day. For the relief of after-pains, chloroform is unnecessary, opiates and chloral hydrate usually sufficing for that purpose. The new-born infant rarely exhibits any unfavorable consequences from inhalation by the mother. It is, nevertheless, possible for chloroform to enter the blood in the placenta, and to find its way into the fœtal circulation. Hoppe-Seyler has demonstrated the presence of chloroform in the urine of a new-born child. Long-continued inhalation of large quantities of chloroform are, therefore, not without danger to the life of the infant. Puerperal convulsions require the induction of complete insensibility, in connection with other appropriate medical treatment. Chloroform is ordinarily employed for this purpose, but when prolonged anæsthesia is required, ether should be given. The contra-indications to the use of anæsthetics during labor are the same that should preclude their use under other circumstances.

Artificial Anæsthesia in Dentistry.—The search for means of obviating the pain attending the extraction of teeth, was the prime cause of the utiliza-

tion of nitrous oxide and of ether. The defective apparatus employed at that time was doubtless one of the causes which led to the disuse of Dr. Wells's discovery. It was nearly twenty years after the experiments of the Hartford dentist, before nitrous oxide was finally established as the dental anæsthetic. During the interval, ether had been introduced into the operations of dentistry by Dr. Morton, but its place was soon taken by chloroform. The great mortality consequent upon the use of this agreeable substance, produced a reaction of feeling against its use, but it was only after Colton had shown the superior safety of laughing-gas that chloroform was finally abandoned by the dental profession. The brevity of the period of insensibility produced by nitrous oxide, especially commends its employment for all operations as short as the extraction of a tooth. For the major operations of dentistry, ether is generally preferred.

Local Anæsthesia.

Numerous attempts have been made to escape from the dangers of general anæsthesia, by the substitution of local anæsthetic and refrigerant applications, for inhalation of generally stupefying vapors. The well-known effects of cold were thus utilized by James Arnott. Freezing mixtures of ice and salt (two parts of pounded ice and one of salt), applied to the surface of the body, soon produce congelation of the part. The skin turns white and tallowy, and the part becomes completely insensible. It is necessary to apply the mixture in a gauze bag, to permit the free escape of the resulting liquid. Unfortunately, the great difficulty of limiting the extent of refrigeration must always serve to restrict the usefulness of this method. If it be desired to produce insensibility extending to the deeper parts of a limb, it will be difficult to dispense with a degree and a duration of cold which must endanger the vitality of the superficial tissues. Arnott's method, therefore, has found comparatively little favor, and local anæsthesia was not generally employed until B. W. Richardson (in 1866) introduced to English surgeons the method of producing local anæsthesia by the concentration of an ethereal spray upon the part to be deprived of sensibility. This operation is easily performed with an ordinary hand-ball atomizing apparatus. The rapid evaporation of ether thus pulverized, produces refrigeration of the tissues with which it is brought in contact, by abstraction of the heat which they contain. For this reason the more volatile ethers are to be preferred. Richardson employed a mixture of anhydrous ether, sp. gr. 0.720, and amylic hydride. Henry J. Bigelow, of Boston, recommended the use of rhigolene, one of the products resulting from the distillation of petroleum. Its specific gravity is only 0.625, and the liquid will boil in the palm of the hand. Complete congelation of the tissues renders it difficult to operate upon them in the usual way. Richardson finds it necessary to discard the knife, and to supply its place with curved scissors. It is not easy to discover the severed bloodvessels in a mass of frozen flesh, and their ligation after the parts have thawed is always painful. For all the graver operations of surgery, general anæsthesia must therefore be preferred.

Carbonic acid gas has been used from time immemorial as a local anodyne. The stone of Memphis, and the familiar yeast poultice, owe their virtues to the local anæsthetic effect of this gas. The good effects of aërated waters, effervescent wines, kumyss, and fermenting paste, in irritable conditions of the gastric mucous membrane, are in great measure due to the carbonic acid which they contain. For a brief period the pains of uterine cancer have been alleviated by injection of water charged with this gas.

The effect of the local application of the ethereal anæsthetics is exceedingly variable, depending chiefly upon the degree of volatility of the substance. Chloroform is for this reason, as well as for its own intrinsic qualities, more potent than ether. When hindered from evaporation by covering the part with oiled silk, the local effect of the anæsthetic is greatly intensified. As a general rule, the more rapid the evaporation of the substance, the less persistent is its anæsthetic effect. Diluted with oil, or combined with unguents, the powerful agents, like chloroform, may be employed with excellent effect for the relief of dermal pains and superficial neuralgias. Pure chloroform applied to the skin produces a powerful counter-irritant effect by virtue of its directly stimulant action upon the cutaneous nerves and capillaries. The burning sensation thus aroused is soon succeeded by cessation of pain, due in part to the local stimulation, and in part to the subsequent diminution of sensibility in the affected nerves. Relief thus obtained is, however, not very permanent, and is restricted to superficial neuralgias alone. For the induction of insensibility sufficient for the painless performance of the major operations of surgery, general anæsthesia must be employed.

Other Modes of Producing Anæsthesia.

Anæsthesia by the Aid of Electricity.—An American dentist, Dr. J. B. Francis, attempted, in 1857, to annul the pain of extracting teeth by passing an electrical shock through the tooth at the instant of its evulsion. After numerous trials, it became clearly evident that this method could avail nothing except by substitution of one form of pain for another. The operation was soon abandoned, and the success of nitrous oxide in dentistry has nearly obliterated the recollection of electrical anæsthesia. The attempt to produce local anæsthesia in surgical operations, by connecting the knife with one of the rheophores of an electrical apparatus, fared no better. The combined action of electricity and local anodynes has been proved to owe all its efficacy to the action of the drugs placed in contact with the skin, and not at all to the electrical current.

Anæsthesia by Rapid Respiration.—A method of producing insensibility by rapid breathing, sufficient for the painless performance of minor surgical operations, has been suggested [by Dr. Bonwill and Dr. A. Hewson]. Since the partial anæsthesia thus induced is largely dependent upon accumulation of blood in the veins, overcharging the vessels of the brain with imperfectly oxygenated blood, the method cannot be commended. In elderly subjects with brittle bloodvessels, cerebral hemorrhage might thus be occasioned. Local anæsthesia should be preferred to this method. It is not improbable that some of the cases of insensibility to pain which are placed in this category, may be really examples of self-hypnotism.

Anæsthesia by Intra-venous Injections.—Ether, chloral, and chloroform, have been frequently administered by hypodermic injection as remedies for neuralgia, and their effects have been highly esteemed by certain observers. The pain which attends the act of injection, and the subsequent danger of abscess, or worse, has prevented the wide extension of this method. Dr. Oré, of Bordeaux, consequently (1872) recommended the use of chloral by intravenous injection, as a means of producing surgical anæsthesia. By the aid of a properly adapted canula and syringe, he slowly introduced into a superficial vein four to ten grammes of chloral hydrate, dissolved in three to five parts

of water. After a period of time varying from six to forty minutes, the patient became completely insensible, and continued in this state for a considerable time. In fifty-three cases reported, the shortest period of anæsthesia was ten minutes; the longest was three hours. Two deaths occurred—one without any visible lesion, the other in consequence of suppurative phlebitis. The difficulties and the danger of this method are thus sufficiently indicated.

Use of Anæsthetic Mixtures.—The risks of cardiac syncope and respiratory paralysis which attend the use of chloroform and the stronger anæsthetics, have occasioned the suggestion of various mixtures designed to stimulate the cardiac and respiratory nervous centres during the act of inhalation. *Oil of turpentine* has been added to chloroform with alleged successful results. Attenuations of chloroform with *alcohol* and *sulphuric ether*, have been extensively employed. Billroth uses a mixture containing three parts of chloroform and one part each of sulphuric ether and alcohol. The London Chloroform Committee recommended (1864) a mixture composed of ether three parts, chloroform two parts, and alcohol one part. Experiments with frogs were said by Sansom to prove that these animals could not be killed with chloroform after they had inhaled the vapor of alcohol. These mixtures, however, do not obviate all danger in the human subject. Several deaths have occurred during their administration. A mixture of *amylic nitrite* and chloroform, in the proportion of sixteen drops to the ounce, has been recommended. Amylic nitrite stimulates the heart, and produces a special impulsion of blood to the head. It has, therefore, been urged that medullary paralysis cannot occur while under its influence. For brief operations this method has been satisfactory, but it is an open question whether the prolonged inhalation of such a mixture may not be quite as dangerous as the use of chloroform alone.

Successive inhalations of *nitrous oxide* and of *ether vapor* have been employed, chiefly in England, by Mr. Clover. The patient is rendered insensible with laughing-gas, and the condition of anæsthesia is then maintained by the substitution of ether or any other anæsthetic vapor. This method has given good results, but it necessitates the use of a complicated inhaling apparatus.

Belladonna, or *atropine*, has been administered, in concurrence with the inhalation of chloroform, to counteract the tendency to syncope while in the anæsthetic state. Theoretically useful, it is hardly probable that a medicinal dose of atropine would be sufficient to protect against a fatal dose of chloroform. The similar employment of *morphine* was introduced in 1863 by Nussbaum, who discovered that surgical anæsthesia could thus be prolonged for several hours. Bernard soon observed the same phenomena in the lower animals. Extending these observations to the human species, he determined the fact that moderate doses of morphine, injected hypodermically half or three-quarters of an hour before inhalation, rendered the induction of anæsthesia less difficult, and caused it to be attended with less than ordinary excitement. Injection immediately before inhalation augmented the period of excitement. Large doses of morphine caused danger of death by asphyxia while under the influence of chloroform. This method of treatment is especially useful in the management of drunkards and other patients who are unduly excited by anæsthetics. When small doses of morphine are employed, the danger of death during anæsthesia is not materially affected; but large doses of the drug add greatly to the peril of this condition. *Chloral hydrate* has sometimes been administered previously to the inhalation of chloroform. The period of excitement is thus abolished; but opinions are divided concerning the safety of patients thus exposed to the concurrent action of two such potent drugs.

Claude Bernard and others have observed that when morphine is injected

hypodermically, before the inhalation of sulphuric ether, the period of excitement is prolonged and rendered more tempestuous, and the subsequent headache and nausea are greatly aggravated. A similar association of chloral hydrate and sulphuric ether gives a less unpleasant result. Insensibility endures for a longer time than when ether alone is employed. Vomiting, however, is very common, and the subsequent prostration and headache are considerably aggravated.

HYPNOTISM.—Certain persons are physically constituted in a manner which leaves their nervous system extraordinarily liable to disturbance of the co-ordinating and connective portions of the apparatus. Accidentally observed at intervals during all ages of the world, this fact has been made the basis of numerous forms of superstition. Brought into notoriety by Mesmer, the phenomena of hypnotism were carefully investigated by Dr. James Braid, of Manchester, between the years 1843 and 1852. Recently his experiments have been repeated by the German physiologists, Heidenhain and Weinhold. By causing a susceptible person to gaze intently for several minutes upon any bright object placed before the eyes, within the limits of distinct vision, a condition of somnambulism, or even of catalepsy, may be induced. In this condition the body becomes insensible to painful impressions, and the voluntary functions of the brain may be completely inhibited. The patient becomes reduced to the condition of an automaton, evolving reflex actions in obedience to the will of the operator. Not all individuals are thus susceptible. Some experimenters have concluded that one person in five was capable of hypnotism. Heidenhain, who experimented only upon males, found that one in twelve could be thus influenced. It is not necessary to address the brain through the eye alone. Gentle friction of the finger tips, or similar stroking of the scalp, or passes of the hand near the surface of the patient, will produce the desired result. A monotonous and continuous sound may also induce this peculiar state. In certain cases a cataleptic state may be set up by simply rubbing or pinching the limb which is to be affected. The patient may retain, in certain cases, the faculty of speech and the power of motion, and yet be insensible to every painful impression. It is while in this condition that surgical operations may be endured without any experience of pain. The susceptibility of the patient to the influence of the operator usually increases with practice, until, at length, a touch with the finger upon some particular portion of the body, or even a glance of the eye, may suffice to reproduce the hypnotic phenomena.

This degree of susceptibility is so frequently associated with ill health, that indulgence in hypnotic sleep has been generally considered injurious to the patient; but the observations of Heidenhain indicate that this is not necessarily the case. The nervous susceptibility may coexist with vigorous health. The duration of the hypnotic paroxysm is quite under the control of the operator. A smart tap upon the shoulder, friction in a direction opposite to the original course, a puff of air in the face, are sufficient to restore the conscious sensibility of the patient. Perrin relates a case in which the patient, from whom a cancerous breast had been removed during the hypnotic trance, was permitted to sleep for forty-eight hours before she was awakened. She had given no evidence of pain at the time of operation, and retained no recollection of anything that had occurred. But, though it is certain that the anæsthesia which forms one of the phenomena of the hypnotic state is sufficient to admit of painless surgery, it is also a fact that the comparatively limited number of individuals who are susceptible must always preclude the general employment of hypnotic anæsthesia as a surgical resource.

Anæsthesia by Compression.—James Moore (1784), and other surgeons since his day, have sought to produce local insensibility sufficient to abolish pain, by compressing the nerves of the part to be operated upon. For this purpose a species of tourniquet has been employed by some, while simple ligation of the member has been proposed by others. Though it is possible thus to produce a certain degree of numbness, the success of the method has been very imperfect, and the whole subject has become a matter of purely historical interest. [Aug. Waller produced muscular relaxation and anæsthesia by compressing the cervical portions of the pneumogastric nerves.]

Mortality consequent upon Artificial Anæsthesia.

It is impossible to reach any degree of certainty regarding this matter. The number of administrations since the discovery of Morton cannot be estimated, and the number of cases which have resulted fatally cannot be ascertained. Hundreds of such cases have been recorded in the medical journals, but many hundred other cases have never been thus reported. All estimates based upon medical literature must, therefore, be regarded as approximations merely. Sufficient, however, is known to enable the surgeon to speak with great assurance regarding the relative dangers which attend the employment of different anæsthetics. Thus, it is certain that chloroform has occasioned the vast majority of deaths which have occurred in connection with artificial anæsthesia. But chloroform has been so much more generally employed than any other anæsthetic, that its mortality, other things being equal, should present a figure greater than that of any other substance. In Europe, the vast majority of surgeons have used chloroform alone. It is in America, where ether has been more generally employed, that a comparison of mortality is more likely to give definite information. Here, however, complete statistics are wanting. A combination of statistical tables is not likely to give additional information, because many of the reported cases of death are repeated in the different tables, while the sum total of inhalations is largely imaginary. The following estimates may illustrate the present condition of our knowledge on the subject.

Dr. J. J. Chisolm, of Baltimore, estimates (1877) that among over 250,000 recorded administrations of *chloroform*, only twelve deaths had occurred. But, since over three hundred fatal cases—Dr. Turnbull (1879) gives a total of three hundred and seventy—have been recorded, if these had been added to Dr. Chisolm's collection, his estimate of the ratio of mortality would have been seriously affected. Prof. E. Andrews, of Chicago (1870), collected 117,078 cases of chloroform inhalation with 43 deaths, giving a ratio of 1 to 2723. Among 92,815 cases of ether inhalation were 4 deaths, giving a ratio of 1 to 23,204. A mixture of chloroform and ether, used in 11,176 cases, caused 2 deaths, giving a ratio of 1 to 5588. Bichloride of methylene, used in 7000 cases, caused one death. Dr. Coles, of Virginia, reported, on the basis of English and American statistics, the following figures: Ether, 4 deaths in 92,815 inhalations; ratio, 1 to 23,204. Chloroform, 52 deaths in 152,260 inhalations; ratio, 1 to 2873. Mixture of chloroform and ether, 2 deaths in 11,176 inhalations; ratio, 1 to 5588. Bichloride of methylene, 2 deaths in 10,000 inhalations; ratio, 1 to 5000. Richardson collected from English hospital statistics, between the years 1848 and 1869 inclusive, a report of 35,165 administrations of chloroform, with 11 deaths, giving a ratio of 1 to 3196. Squibb has estimated the ratio of deaths by chloroform published in American journals at 1 to 11,764. Assuming that only half the fatal cases are reported, this would give a ratio of 1 to 5882. A more favorable showing is made by the Royal Infirmary of

Edinburgh, where it is reported that during a period of ten years only one death occurred in an estimated total of 36,500 administrations of chloroform. Rendle estimates that in twenty of the principal London hospitals chloroform is administered about eight thousand times each year, with a mortality of three per annum. This would yield a ratio of 1 to 2666, which agrees very closely with Richardson's later estimates.

The well-known assertion that, during the Crimean war, not a single fatal case of anæsthesia occurred among the 20,000 patients who were chloroformed in the French army, may be received with a certain degree of reserve, for, in military practice, it is not always easy to assign due weight to the different causes which may co-operate to produce a fatal result. It is admitted by the highest American authorities that, during the war of the rebellion, seven fatal cases resulted from eighty thousand inhalations of chloroform, giving a ratio of 1 to 11,448. Kappeler reports for himself and for three other German surgeons—Billroth, Nussbaum, and König—about thirty-nine thousand administrations of chloroform, with but two fatal cases. This would give a ratio of 1 to 19,500. The same author admits the insufficiency of German reports concerning the mortality after use of chloroform. Much allowance must be made for the personal equation of each surgeon in estimating the value of individual experience in this matter. If now the above statistics, excluding the earlier tables of Andrews and Coles, be consolidated, a total of 218,165 inhalations of chloroform gives a mortality of twenty-four cases. This yields a ratio of 1 to 9090, which is probably the most favorable award that can be made to chloroform. (See *Note*, p. 433.)

Information regarding the actual mortality caused by *sulphuric ether*, is no more easily discovered than in the case of chloroform. Kappeler could discover only thirteen fatal cases assigned to ether, and of these thirteen, only four could without contradiction be ascribed to the influence of ether alone. Turnbull has collected the histories of eighteen cases which proved fatal after the inhalation of ether; but of these only nine cases can be fairly charged to the anæsthetic. It is probable that the ratio fixed by Dr. Andrews (1 to 23,204) expresses very nearly the actual risk from ether inhalation. It should be observed in this connection, that such statistical estimates take no cognizance of the innumerable cases in which alarming symptoms, rarely noted after ether, present themselves during the course of anæsthesia from chloroform.

Very little is known regarding the comparative dangers which attend the use of the majority of anæsthetic substances. Many of them have caused death at an early period in the history of their employment, so that they have been laid aside before their fatality could be justly estimated. There appears to be good reason for the belief that the lethal energy of an anæsthetic is closely related to the molecular weight of the substance—increasing directly as its weight increases. The presence of the haloid elements also adds greatly to the deadly efficiency of an anæsthetic compound. *Nitrous oxide*, in spite of its asphyxiating property, is the safest of all anæsthetics for brief operations. This gas has been administered more than a million times, with but seven fatal cases. Used according to the method of Bert [administered in a chamber of compressed air in mixture with oxygen gas], it is theoretically as harmless as atmospheric air.

Post-mortem Appearances after Death from Artificial Anæsthesia.

Excluding the rare cases of asphyxia in which death has been occasioned by the intrusion of a foreign body into the larynx or trachea, and the equally rare cases in which suffocation may have been caused by the use of an ill-con-

structed inhaler, the autopsies of the victims of anæsthesia present nothing positive or characteristic. In such cases, death is the consequence of disturbance of the nervous apparatus concerned in the acts either of respiration or of circulation. The changes which have produced the result are intra-molecular, and are consequently beyond the reach of our senses.

Anæsthetic Substances.

The majority of alcohols and ethers are probably endowed with anæsthetic properties. The number, however, of such compounds which are capable of use in a manner to exhibit this quality, is comparatively limited. The following list includes all that have been tested with any degree of precision. Besides these, a variety of substances which do not belong to the class of alcohols and ethers, are known to possess anæsthetic properties. Nitrous oxide, carbonic anhydride, and various hydrocarbons, are examples of these bodies. It is not unlikely that all substances which possess antiseptic qualities are also capable of producing artificial anæsthesia, if sufficiently diluted. There is wide room for experiment and observation in this field of investigation. The classification here adopted is furnished by Miller's Elements of Chemistry (fifth edition). The formulæ and the descriptions of the different substances are derived either from the same source or from Watts's Dictionary of Chemistry.

I. *Hydrocarbons and their Derivatives.*

From petroleum and from coal, certain binary compounds of carbon and hydrogen may be separated by distillation. These are either gaseous and present in illuminating gas, or liquid and separable by fractional distillation from the kindred compounds with which they are associated in crude petroleum. A number of these substances have been isolated, and separately tested in the production of artificial anæsthesia. Others, like keroselene, have been used in their natural combinations.

The lowest member of the series is Methane, CH_4, sometimes called *methylic hydride*, *marsh gas*, or *light carburetted hydrogen*. It is one of the products of the destructive distillation of wood, peat, soft coal, and other allied substances. It is one of the principal constituents of illuminating gas. It is a colorless, inodorous, tasteless gas, sp. gr. 0.5576, respirable with safety if diluted with air. It is never thus used, unless by accidental breathing of coal gas. The derivatives of this radical are among the most important anæsthetics.

Ethane, C_2H_6, *Ethylic hydride*, or *Dimethyl*, is a tasteless, and odorless gas with a specific gravity of 1.075. It is chiefly interesting as the radical of the ethylic series of alcohols, aldehydes, ethers, etc.

Tetrane, C_4H_{10}, *Butane*, *Diethyl*, *Butylic hydride*, is a liquid derived by fractional distillation from petroleum. The vapors must be condensed at a low temperature, for the boiling point of the liquid is 1° C. (33°.8 F.). Dissolved in naphtha, the solution constitutes *rhigolene*, a colorless liquid which evaporates with great rapidity, boiling in the palm of the hand. It has been used for the production of local anæsthesia by the evaporation of its spray. *Keroselene* is a colorless liquid, with a variable composition, derived by distillation from petroleum. It is chiefly composed of higher members of the paraffin series, such as amylic, caprylic, œnanthylic, laurylic, myristilic and palmitylic hydrides. Inhalation of its vapor produces disagreeable and

alarming symptoms, so that it may be justly discarded from the list of useful anæsthetics.

PENTANE, C_5H_{12}, *Amylic hydride*, is a colorless liquid, boiling between 37° and 39° C. (98°.6 and 102°.2 F.). Its specific gravity is 0.626. It is one of the constituents of naphtha and of rhigolene. Inhalation of its vapor is followed by speedy anæsthesia, without disagreeable consequences. It has been successfully used in dental surgery, but its extreme volatility is an objection to its general employment.

OCTANE, C_8H_{18}, *Caprylic hydride*, has also been isolated from keroselene or from petroleum. It is a colorless liquid, with a specific gravity of 0.728. Its boiling point is uncertain; 115°–125° C. (239°–257° F.). Administered to animals, it produces a long period of excitement, often accompanied by vomiting.

The substances above mentioned belong to the *paraffin* series of hydrocarbons. The *olefin* series of hydrocarbons has yielded two substances whose anæsthetic properties have been recognized—ethylene and amylene.

ETHYLENE, C_2H_4, *Olefiant gas*, *Heavy carburetted hydrogen*, *Elayl*. This is one of the most important luminous constituents of *coal-gas*. It is a transparent, colorless gas, with a faint, sweetish, alliaceous odor, and is soluble in about 12 times its bulk of cold water. Its specific gravity is 0.978. Liquefied under great pressure, it remains unfrozen at —110° C. (—166° F.). Associated with methane, butylene, acetylene, hydrogen, carbonic oxide, and a variable volume of impurities, it constitutes a part of the gaseous mixture used for illuminating purposes. *Illuminating gas*, when inhaled in considerable quantity, produces muscular rigidity, contraction of the pupils, injection of the cutaneous vessels, rapidity of the pulse, snoring respiration, and complete insensibility. Continued inhalation produces dilatation of the pupils, muscular relaxation, vomiting, and death. The fatal issue results in part from the asphyxiating property of the impurities contained in the gas, and in part from the directly toxic effect of its various ingredients.

AMYLENE, C_5H_{10}, *Pentylene*, or *Pentene*. Sp. gr. 0.6549. Boiling point, 39°–42° C. (102°.2–107°.6 F.). A transparent, colorless, mobile liquid, with an offensive, cabbage-like odor. It burns with a luminous flame, is almost insoluble in water, but mixes in all proportions with alcohol or ether. It may be distilled from a mixture of zinc chloride and amylic alcohol, and it also exists as a constituent of petroleum. The condition of insensibility produced by inhalation of its vapor is less persistent than the effect of chloroform. Muscular spasms are likely to occur under its influence. Snow administered it in more than one hundred cases; but, two deaths occurring as a consequence of its use, it was entirely abandoned.

HYDROCARBONS OF THE TERPENE SERIES are represented by *Turpentine oil*, $C_{10}H_{16}$. This is a colorless, mobile liquid with a peculiar, aromatic odor, and is obtained by distillation of the oleo-resinous juices of certain species of Pinus. Its specific gravity is 0.86, and it boils at 150°–160° C. (302°–320° F.). It has been recommended in combination with chloroform as a means of preventing syncope during anæsthesia. Administered to animals, it produces complete insensibility without unfavorable consequences. Its effects are slowly evolved, and it sometimes produces local irritation of the respiratory and urinary passages.

HYDROCARBONS OF THE BENZENE SERIES. *Benzene*, C_6H_6, *Benzol*, *Phenylic hydride*. Sp. gr. at 0° C. (32° F.), 0.8995. Boiling point, 80°.5 C. (176°.9 F.). A colorless, limpid, strongly refracting liquid, of a peculiar and rather agreeable odor. Its vapor is very inflammable, burning with a luminous and smoky flame. The substances generally sold under the names of *benzine* and *benzoline* are chiefly mixtures of paraffins, and do not contain benzene. It

may be obtained by the distillation of benzoic acid with calcic hydrate at a dull red heat, but on the large scale it is prepared from the portion of coal-tar oil which boils below 100° C. (212° F.). As an anæsthetic it may be used to produce insensibility when inhaled, but it produces disagreeable sensations, muscular twitching, and even convulsions.

Haloid Derivatives of the Hydrocarbons.—Monochloromethane, CH_3Cl, *Methylic chloride.* Sp. gr. of gas, 1.736. Boiling point, —22° C. (—7°.6 F.). A colorless gas, prepared by passing hydrochloric acid into a boiling solution of zincic chloride in twice its weight of methylic alcohol. A solution of this gas in ordinary ether has been employed experimentally as an anæsthetic. It is an agreeable but not very efficient substance.

Dichloromethane, CH_2Cl_2, *Methylenic chloride, Methylene bichloride.* Sp. gr. 1.36. Boiling point, 40°–42° C. (104°–107°.6 F.). A colorless liquid, with an odor resembling that of chloroform. Prepared by acting upon monochloromethane with chlorine in bright sunshine, or by treating di-iodo-methane, CH_2I_2, with chlorine. Its effects are very similar to those of chloroform inhalation. Owing to the low boiling point of the liquid, it cannot be economically employed during very warm weather. Its effects are for the same reason very evanescent. Four cubic centimetres are sufficient to produce insensibility. No unpleasant sensations ordinarily accompany the return to consciousness. Vomiting is less frequent than after chloroform or ether. This anæsthetic has been extensively employed by Spencer Wells, in England, but other surgeons have been less enthusiastic, and numerous deaths caused by its administration have been reported in the English medical journals. It is, probably, little less dangerous than chloroform.

Trichloromethane, $CHCl_3$, *Chloroform.* Sp. gr. 1.497. Boiling point 61° C. (142° F.). A colorless, volatile liquid, with high refracting power, an agreeable, ethereal odor, and a sweet, penetrating taste. Very sparingly soluble in water, it dissolves in every proportion in alcohol or in ether. Set on fire with difficulty; it burns with a greenish, smoky flame. Pure chloroform should communicate no color to sulphuric acid when agitated with it. The liquid should be colorless, and destitute of any chlorous odor. When evaporated from the hand, no unpleasant odor should remain. Chloroform is an excellent solvent for sulphur, phosphorus, iodine, fats, and resinous bodies. It is the most perfect solvent for caoutchouc. Chloroform is manufactured by acting upon dilute alcohol with chloride of lime. Wood spirit, acetone, oil of turpentine, and many essential oils, likewise yield it when treated with bleaching powder. It may be administered internally in the liquid form, largely diluted, in doses not exceeding four cubic centimetres. Administered by inhalation, it may be evaporated drop by drop from a napkin placed before the face. The vapor must be largely diluted with air. More than five per cent. of the vapor in the air of respiration is liable to produce alarming symptoms. The agreeable odor of chloroform, its pleasing effects upon the brain, the energy and rapidity of its action, and the concentration of the liquid, have rendered it the favorite anæsthetic. The high rate of mortality which accompanies its use has rapidly depressed its value in the estimation of an increasing number of surgeons, and has greatly stimulated the search for a safer anæsthetic which shall still possess the admirable qualities of chloroform.

Tetrachloromethane, CCl_4, *Carbonic tetrachloride.* Sp. gr. 1.599. Boiling point 78° C. (172°.4 F.). A colorless liquid, obtained from wood spirit and chloroform by the action of chlorine in bright sunshine. It is insoluble in water, but soluble in alcohol and in ether. Employed as an anæsthetic, its action is less rapid and more persistent than the action of chloroform. Its sensible effects are less agreeable, and its effect upon the heart is more energetic

than that of chloroform. It is powerfully irritant to the nervous system, producing tonic and clonic convulsions, rapid and irregular action of the heart, and arrest of respiration. Its general action is similar to that of chloroform, but its depressing action upon the heart is much greater, so that it must be considered a more dangerous substance.

IODOMETHANE, CH_3I, *Methylic iodide.* Sp. gr. 2.2. Boiling point 42° C. (107°.6 F.). Vapor density 4.833. A colorless, mobile liquid, of peculiar ethereal odor, insoluble in water, prepared by distillation from a mixture of 100 parts of iodine with 50 parts of methylic alcohol and 7 parts of amorphous phosphorus. Chemically pure, its vapor is respirable and anæsthetic; but it is exceedingly unstable, yielding excessively irritating fumes, and producing very disagreeable effects.

TRI-IODOMETHANE, CHI_3, *Iodoform.* Melting point, 120° C. (248° F.). A product of the action of iodine, in presence of potassic or sodic hydrate or carbonate, on ethylic alcohol, aldehyde, acetone, and many other substances. It exists in greenish-yellow, scale-like crystals, with a sweetish taste, and a peculiar odor which may be masked by the oil of peppermint. Its properties are discutient, antiseptic, and anæsthetic. Applied locally, it diminishes the sensibility of the skin, and of irritable surfaces generally. All varieties of unhealthy, offensive, and painful ulceration are benefited by its topical application. Administered internally, in small doses, it is rapidly eliminated without producing any signs of irritation. Doses of half a gramme (eight grains) produce in man a diminution of the frequency of the pulse. If continued for any considerable period of time, somnolence may result. Given to animals—four grammes to a dog—it produces muscular relaxation, anæsthesia, insensibility, and death. Muscular rigidity may also be observed.

MONOCHLORETHANE, C_2H_5Cl, *Ethylic chloride, Hydrochloric ether.* Sp. gr. 0.920. Boiling point, 12°.18 C. (53°.92 F.). Vapor density, 2.219. A thin, colorless liquid, with a pungent, ethereal odor, and a sweetish, aromatic taste. It is very inflammable, evolving hydrochloric acid from a brilliant, green-edged flame. It is the first product of the action of chlorine upon ethane in diffused daylight. In spite of its remarkable volatility, this substance has been employed as an anæsthetic in a number of operations. Its general effects correspond very closely with the effects produced by ordinary ether. Given to rabbits, it produces rapid anæsthesia, but it has caused in these animals cessation of respiration, and general convulsions.

DICHLORETHANE, $C_2H_4Cl_2$. Two isomeric dichlorethanes are known: (α) *dichlorethane*, or *ethylenic chloride*, $CH_2Cl.CH_2Cl$; and (β) *dichlorethane*, or *ethylidenic chloride*, $CH_3.CHCl_2$.

(α) *Ethylenic chloride, Ethylene dichloride, Dutch liquid.* Sp. gr. 1.256. Boiling point, 84° C. (183°.2 F.). Vapor density, 3.4434. A colorless, neutral, oily liquid with a fragrant, ethereal odor and a sweetish, aromatic taste. It is formed by the action of chlorine upon ethylene. The resulting compound is anæsthetic, but its vapor is irritating, and sometimes causes vomiting. In the lower animals it may produce convulsive movements without anæsthesia. It possesses no advantages over chloroform.

(β) *Ethylidenic dichloride, Ethylidene chloride, Ethidene dichloride.* Sp. gr. 1.174. Boiling point, 60° C. (140° F.). Vapor density, 4.954. A colorless, oily liquid, resembling chloroform in taste and odor, produced by acting on monochlorethane with chlorine, and also by treating aldehyde with phosphoric pentachloride. Its anæsthetic action is very rapid, producing insensibility in one minute—seldom requiring to be inhaled as long as three minutes. Recovery is speedy, and disagreeable after-effects are rarely experienced. The heart is less liable to depression under the influence of ethylidenic chloride than when chloroform is employed. It is, nevertheless, a cardiac poison, pro-

ducing death by syncope. Administered by Mr. Clover in one thousand eight hundred and seventy-seven cases, it caused one death; and on three other occasions the patient was only saved by inversion and artificial respiration.

TRICHLORETHANE, $C_2H_3Cl_3$, exists in two isomeric forms—(α) *trichlorethane*, $CH_2Cl.CHCl_2$, and (β) *trichlorethane*, $CH_3.CCl_3$.

(α) *Trichlorethane*, *Monochlorethylenchloride.* Sp. gr. 1.422. Boiling point, 115° C. (239° F.). A liquid, having an odor like chloroform, formed by the action of chlorine on dichlorethane, or by the action of chlorovinyl (C_2H_3Cl) on perchloride of antimony. It is readily decomposed with potassa into potassic chloride and dichlorethylene. The vapor of a few drops is sufficient to produce rapid anæsthesia in frogs, pigeons, guinea-pigs, and rabbits. Dogs weighing five or six kilogrammes are rendered insensible in three to seven minutes by the vapor of thirty to fifty drops of the liquid. The duration of such anæsthesia varies from eleven to nineteen minutes. In one case, reported by Tauber, of Jena, the pulse was considerably accelerated; slightly in three others. In no instance was it retarded. Respiration was either accelerated or but very slightly diminished. The kymographion exhibited no diminution of blood-pressure.

(β) *Trichlorethane*, *Monochlorethylidenchloride*, *Methylchloroform.* Sp. gr. 1.372. Boiling point 75° C. (167° F.). A liquid, resembling chloroform in odor and appearance, produced by the action of chlorine on monochlorethane. With this substance, Tauber, of Jena, has recently experimented upon animals and upon himself. Frogs and rabbits were quickly rendered insensible without special modification of either circulation or respiration. A dog, weighing five or six kilogrammes (ten or twelve pounds), was rendered completely insensible for nineteen minutes by the vapor of forty or fifty drops of the liquid. Respiration was somewhat accelerated during the period of most profound insensibility, but the pulse was very slightly disturbed. The vapor of two hundred drops (twenty grammes), administered to Dr. Tauber, caused anæsthesia in five minutes and thirty seconds. It continued for ten minutes. There was no preliminary stage of excitement. Respiration remained quiet and normal. The pulse did not exceed 84, and continued undisturbed throughout the experiment. Recovery was attended with vomiting, and with a feeling of discomfort which lasted for an hour.

ARAN'S ETHER, $C_2H_3Cl_3 + C_2H_2Cl_4$, *Ether anæstheticus*, is a mixture of trichlorethane and tetrachlorethane. Its specific gravity varies from 1.55 to 1.6. Its boiling point is about 130° C. (266° F.). In appearance and properties it resembles chloroform.

MONOBROMETHANE, C_2H_5Br, *Ethylic bromide*, *Bromide of ethyl*, *Hydrobromic ether.* Sp. gr. 1.4733. Boiling point, 40°.7 C. (105°.26 F.). Vapor density, 3.754. A colorless, neutral liquid, with ethereal odor and a disagreeably sweetish taste. Sparingly soluble in water, it mixes readily with alcohol and ether. It is ignited with difficulty, giving a green flame without smoke, evolving a strong smell of hydrobromic acid. Its vapor is powerfully anæsthetic, producing insensibility in animals in less than a minute. Its effects pass off very rapidly. Circulation and respiration are profoundly modified by its depressing action. To adult human beings it may be administered upon a napkin in doses of four cubic centimetres (one drachm) at once. The excessive volatility of the liquid requires almost total exclusion of air during inhalation. Owing to the instability of the substance, it is liable to become contaminated with carbon bromide and free bromine. Great irritation may be excited by inhalation of these impurities. This fact, in connection with the recent occurrence of death in two instances of its use, has led to the almost total abandonment of the drug as a general anæsthetic.

IODETHANE C_2H_5I, *Ethylic iodide*, *Iodide of ethyl*, *Hydriodic ether*. Sp. gr. 1.97. Boiling point 72°.5 C. (162°.5 F.). Vapor density, 5.475. A colorless, ethereal liquid, prepared by distillation from a mixture of ethylic alcohol, amorphous phosphorus, and iodine. It soon decomposes, turning red or brown from the liberation of iodine. Its vapor is useful in chronic bronchitis and in certain cases of asthma. It has been occasionally employed as a general anæsthetic, but its instability is sufficient to disqualify it for such use.

MONOCHLOROTETRANE, C_4H_9Cl, *Butylic chloride*. Sp. gr. 0.88. Boiling point, about 70° C. (158° F.). An ethereal liquid, with an odor recalling that of chlorine, may be obtained by distilling amylic alcohol with calcic hypochlorite. Its vapor, administered to rabbits, overpowers respiration and weakens the cardiac pulsations until they cease altogether.

Isobutylic chloride, $CH(CH_3)_2CH_2Cl$, is a compound isomeric with the preceding substance. Its specific gravity is 0.895; its boiling point is 60° C. (140° F.). Prepared by treating isobutylic alcohol with hydrogen chloride, or with phosphorus pentachloride, it is a limpid liquid, with a pleasant, ethereal, but slightly alliaceous odor. Administered to frogs, rabbits, and dogs, it produced anæsthesia in from three to five minutes. Respiration was unaffected, and cardiac pulsation was not weakened.

MONOCHLOROPENTANE, $C_5H_{11}Cl$, *Amylic chloride*, *Chloride of amyl*. Sp. gr. 0.699. Boiling point 101° C. (213°.8 F.). Vapor density 3.8. Three isomeric monochlorinated compounds of pentane exist, differing slightly in specific gravity and boiling point. The substance which is employed as an anæsthetic has been tested by Snow and Richardson. It is administered in quantity similar to chloroform, and produces a gradually developed and long-continuing anæsthesia, without specially disagreeable consequences.

MONO-IODOPENTANE, $C_5H_{11}I$. *Amylic iodide*, *Iodide of amyl*. Sp. gr. 1.511. Boiling point 146° C. (294°.8 F.). Vapor density 6.675. A colorless liquid, with faint odor and pungent taste, turning brown on exposure to light. It is prepared by treating amylic alcohol with iodine and phosphorus. Though possessed of anæsthetic properties, its instability disqualifies it for practical use.

NITROPENTANE, $C_5H_{11}NO_2$. *Amylic nitrite*, *Nitrite of amyl*. Sp. gr. 0.877. Boiling point 96° C. (205° F.). A clear, colorless liquid, prepared by heating pure amylic alcohol with nitric acid. It has a peculiar odor, suggestive of apples and bananas. Administered drop by drop, in vapor, it powerfully excites the heart, and dilates the bloodvessels, especially of the head. The stage of excitement is followed by diminution of cardiac energy and collapse of the terminal vessels. Consciousness disappears before death when the drug is given in poisonous doses. Complete anæsthesia does not occur until shortly before death. The use of this substance is specially indicated in diseases characterized by spasmodic or excessive, tonic contraction of the vascular coats in any part of the body, such as the angiospastic variety of hemicrania, angina pectoris, or epilepsy. Its stimulant effect upon the heart has led to its employment in the syncope induced by chloroform.

PYRROL, C_4H_5N. Sp. gr. 1.077. Boiling point 133° C. (271°.4 F.). A nitro-hydrocarbon found in coal tar. It is produced whenever animal or vegetable substances containing nitrogen are subjected to destructive distillation. It is a colorless, transparent liquid, with a delightfully fragrant odor, resembling chloroform, but softer and less pungent. Its taste is hot and pungent. Administered to small animals, its vapor produces great excitement and muscular spasms, succeeded by imperfect anæsthesia.

II. *Alcohols.*

METHYLIC ALCOHOL, $CH_3.OH$. *Wood spirit, Pyroxylic spirit.* Sp. gr. 0.8142. Boiling point 58.6° C. (137°.4 F.). A limpid, colorless, inflammable liquid, with a penetrating, spirituous odor, and a disagreeable, burning taste. It is usually prepared from the crude wood vinegar obtained by the dry distillation of hard wood at a high temperature in closed vessels. Its vapor produces headache, dizziness, and nausea. Taken in the liquid form, it may produce intoxication and insensibility resembling that produced by ordinary alcohol.

ETHYLIC ALCOHOL, $CH_3.CH_2OH$. *Alcohol. Spirit of wine.* Sp. gr. 0.8095, 0.7938 at 15°.6 C. (60° F.). Boiling point, 78°.3 C. (173° F.). Vapor density, 1.613. A colorless, volatile, inflammable liquid, with an agreeable, spirituous odor and burning taste, obtained by distillation from saccharine solutions which have undergone fermentation. A stimulant in small doses, large quantities of the liquid produce depression of temperature, enfeeblement of the heart, general anæsthesia, unconsiousness, and even death itself.

PHENOL, $C_6H_5.OH$, *Oxybenzene, Phenylic hydrate, Carbolic acid.* Sp. gr. 1.056. Boiling point, 182° C. (359°.6 F.). Obtained by purification of the product of distillation of the *dead oil* of coal tar. It crystallizes in long colorless needles which melt at about 39° C. (102°.2 F.). Its odor is characteristic though not disagreeable. It is moderately soluble in water, and does not redden litmus. It is extremely soluble in alcohol, ether, acetic acid, carbon disulphide, chloroform, and hydrocarbons of the benzene series. It coagulates albumen, and prevents fermentation and putrefaction. Applied to the healthy skin it excites a burning sensation, whitens the surface, and produces local anæsthesia sufficient to render superficial incisions painless. Administered internally it produces acceleration of the circulation and respiration, followed by more or less general anæsthesia. Poisonous doses—thirty grammes (an ounce) or more—produce caustic effects in the mouth, œsophagus, and stomach, followed by feeble pulse, livid skin, insensibility, collapse, and death. Fatal consequences have followed the external use of this substance when used in large quantities with surgical dressings.

TRICHLORETHALDEHYDROL, $CCl_3.CH(OH)_2$, *Chloral hydrate.* Boiling point, 96° C. (204°.8 F.). Produced by the action of chlorine on a well cooled aqueous solution of aldehyde. It crystallizes in large monoclinic prisms, soluble in water. Administered by the mouth, or injected into a vein, it produces deep sleep. This action has been attributed to its conversion into chloroform and formic acid in the blood. There is, however, not sufficient reason to accept this explanation. It reduces the temperature, lessens blood pressure, lowers the rate of respiration and circulation, relaxes spasm, and induces sleep, but does not produce complete anæsthesia unless administered in dangerous doses. It is a powerful irritant when applied locally to the skin or mucous membranes. Its hypodermic use is liable to cause pain and sloughing. As a hypnotic, it may be given in doses of one or two grammes (fifteen to thirty grains). Death has been known to result from ten grains, but recovery has also occurred after taking 165 grains, or even 350 grains. As an anodyne, chloral hydrate is inferior to opium.

TRICHLOROBUTALDEHYDROL, $C_3H_4Cl_3.CH(OH)_2$, *Butylchloral hydrate.* A substance closely resembling chloral hydrate in appearance, crystallizing from water in thin, glistening, white plates which melt at 78° C. (172°.4 F.). It is prepared from ethylic aldehyde by the action of chlorine, which first produces trichlorotetraldehyde. The addition of water occasions the formation of butylchloral hydrate. The effect of this substance closely resembles the

effects produced by chloral hydrate. It, however, produces marked insensibility of the nerves of the head and face. This has given the drug a certain reputation in the treatment of facial neuralgia. The ordinary soporific dose is about gm. 0.20 (three grains), repeated at intervals of an hour. Excessive doses may prove fatal by arresting the movements of respiration.

III. *Ethers.*

METHYLIC ETHER or *Oxide of methyl*, $CH_3.O.CH_3$. A colorless gas, with a pleasant, ethereal odor, it may be condensed by cold or by pressure to a liquid boiling at about —21° C. (—5°.8 F.). It is not used in surgery, but its solution in ether has been tested under the name of *methyl-ethylic ether.* The vapor of this substance produces anæsthesia without agitation, spasm, or convulsion. Small animals killed by its inhalation die from paralysis of respiration. Its odor and its extreme volatility furnish the principal objections to its use.

ETHYLIC OXIDE, $C_2H_5.O.C_2H_5$, *Ethylic ether*, *Ether*, *Sulphuric ether.* Sp. gr. 0.736. Boiling point, 35°.5 C. (95°.9 F.). Vapor density, 2.586. A colorless, transparent, mobile liquid, with a peculiar, exhilarating odor and sharp, burning taste, with a cooling after-taste. It is formed by the action of sulphuric acid upon ethylic alcohol. The primary effect of ether inhalation is excitement. The pulse and respiration are accelerated; the mucous surfaces are irritated; there is a disposition to muscular movement; the brain is excited. This stage is soon followed by a diminution and perversion of general sensibility. The sense of pain is overcome before the sense of touch. The special senses soon yield; the muscular apparatus is relaxed; the pupils are contracted; the face suffused; the skin becomes moist; consciousness ceases. In this stage the circulation and respiration recede towards the normal standard, and tend towards a uniform rate. In profound anæsthesia the respiration may become stertorous and slow; the pulse falls and weakens; the skin is cool, moist, and pale—sometimes cyanotic. In the rare instances of death from inhalation of ether, the fatal result is due to arrest of the functions of respiration and circulation. [Under the name of "first insensibility from ether," Dr. Packard, of Philadelphia, has described a condition of brief duration in which certain operations, such as opening an abscess, can be performed without pain to the patient, though the administration of the anæsthetic has not been pushed to the extent of producing complete insensibility. A similar condition of "primary anæsthesia" from the use of chloroform, has been noticed by Dr. Gibney, of New York.]

METHYLAL, $CH_2(OCH_3)_2$, *Methylene dimethyl ether.* Sp. gr. 0.8551. Boiling point, 42° C. (107°.6 F.). Vapor density, 2.625. A colorless, ethereal liquid, obtained in small quantity by distilling methylic alcohol with sulphuric acid and manganic peroxide. It possesses decided anæsthetic properties, but is less agreeable and less manageable than chloroform.

IV. *Ethereal Salts.*

ETHYLIC NITRATE, $C_2H_5.NO_3$, *Nitric ether.* Sp. gr. 1.112. Boiling point, 85° C. (185° F.). Vapor density, 3.112. A colorless liquid with an agreeable odor, and a taste at first very sweet, but followed by a bitterish after-taste. It is obtained by distillation from a mixture of alcohol and nitric acid with urea. The vapor of fifty or sixty drops produces anæsthesia, followed

by such disagreeable dizziness, headache, and general discomfort that its use cannot be recommended.

Ethylic Formate, $C_3H_6O_2$, *Formic ether.* Sp. gr. 0.918. Boiling point, 54°.9 C. (130°.8 F.). Vapor density, 2.573. A colorless liquid with an agreeable, pungent odor, formed by distilling a mixture of formic acid and ethylic alcohol with sulphuric acid. It is supposed to act by decomposition into alcohol and alkaline formiates in the blood. Upon animals its effect is similar to that of alcohol. Doses of six or eight cubic centimetres (a drachm and a half to two drachms), given to the human subject, produce only drowsiness.

Ethylic Acetate, $C_4H_8O_2$, *Acetic ether.* Sp. gr. 0.906. Boiling point, 77° C. (170°.6 F.). Vapor density, 3.047. A colorless liquid which has a pleasant, fruity odor when diluted with alcohol or water. It is obtained by distilling a mixture of ethylic hydric sulphate and sodic acetate. Less volatile and less inflammable than ordinary ether, it produces anæsthesia in small animals with less previous agitation than when ether is used. It may be employed in doses similar to those of sulphuric ether.

V. *Aldehydes.*

Ethaldehyde, $CH_3.COH$, *Acetic* or *Ethylic aldehyde, Aldehyde.* Sp. gr. 0.801. Boiling point, 22° C. (71°.6 F.). Vapor density, 1.532. Produced by the action of nearly every oxidizing agent on ethylic alcohol, this substance is a colorless, mobile, inflammable liquid, with a characteristic, pungent, not disagreeable odor. Inhalation of its vapor produces a sense of constriction about the chest, and distressing irritation of the respiratory passages, with a marked tendency to arrest of respiration. It is a powerful anæsthetic, producing insensibility in about two minutes; but its effects are disagreeable and dangerous.

VI. *Ketones.*

Dimethyl Ketone, $CH_3.CO.CH_3$, *Acetone.* Sp. gr. 0.814. Boiling point, 56°.3 C. (133°.3 F.). Vapor density, 2.0025. A limpid liquid possessing an agreeable odor, and a biting taste like peppermint. Prepared by various processes, it is most conveniently obtained by the dry distillation of calcic acetate. Its vapor is slightly anæsthetic to frogs. Inhaled by the human subject, it produces soporific effects associated with dyspnœa and irritation of the air-passages.

VII. *Inorganic Substances.*

Nitrogen, N. Sp. gr. 0.971. A colorless, tasteless, odorless gas. Its reaction is neutral with litmus, and it is neither inflammable nor a supporter of combustion. It may be readily inhaled in an undiluted form. It thus produces simple, uncomplicated asphyxia. Such insensibility as follows its inhalation is merely one of the preliminaries of death by asphyxia. For this reason, nitrogen cannot strictly be considered an anæsthetic substance.

Nitrous Oxide, N_2O, *Laughing gas.* Sp. gr. of gas, 1.527. Sp. gr. of liquid, 0.908. Boiling point of liquid, —88° C. (—126°.4 F.). A transparent, colorless gas, with a faint, sweetish smell and taste, prepared by heating ammonium nitrate. It may be liquefied by a pressure of fifty atmospheres at

7° C. (45° F.). Inhalation of the gas produces both asphyxia and anæsthesia; hence it can be respired with safety for a brief period only. It rapidly discharges oxygen from the blood, and produces death by asphyxia. The convulsive phenomena which ordinarily accompany that state are suppressed by the anæsthetic action of the gas upon the convulsive nerve centres. If mixed with atmospheric air during inhalation, great nervous and cerebral exhilaration is produced, without loss of consciousness. The action of the undiluted gas is very prompt, and recovery is equally rapid. Paul Bert has shown that an equal mixture of nitrous oxide and common air, or an equivalent quantity of oxygen, inhaled under a pressure of two atmospheres, will produce complete anæsthesia without asphyxia. Inhalation of the mixture may be safely continued for an indefinite period. By this method the blood receives enough oxygen to sustain life at the same time that it is sufficiently charged with nitrous oxide to produce anæsthesia.

Carbonic Oxide, CO. Sp. gr. 0.967. A transparent, colorless, inflammable, almost odorless gas. It is ordinarily produced by the combustion of coal with a limited supply of oxygen. Its action is exceedingly energetic. The presence of one tenth of one per cent. of this gas in the air is sufficient to destroy a bird, and two or three tenths of one per cent. will kill a dog. It forms a permanent combination with the hæmoglobin of the blood, expelling oxygen, and producing insensibility and death by asphyxia. Resuscitation is rendered almost impossible by the stability of the compound which it forms with hæmoglobin. The stupefying energy of the smoke of burning puff-ball (*Lycoperdon proteus*) is due to the presence of this gas.

Carbonic Anhydride, CO_2, *Carbonic acid gas*. Sp. gr. of the gas, 1.529; sp. gr. of the liquid, 0.83. Boiling point, —78° C. (—109° F.). A colorless, transparent gas, with a slightly acid taste and smell. It may be liquefied and frozen by pressure and cold. It may be liberated from any carbonate by the action of a stronger acid. The gas causes speedy death by asphyxia, if inhaled without dilution. If it exceed three or four per cent. of the air that is breathed, giddiness, dyspnœa, muscular weakness, and feeble and rapid movements of the heart appear. Any considerable increase of the gas intensifies these phenomena, and will destroy life, even though a considerable amount of air be present. Death results partly through exclusion of oxygen from the blood, partly from retention of carbonic acid in the blood, and partly from the directly anæsthetico-toxic action of the substance upon the nervous tissues. A few surgeons have attempted to combine the action of carbonic acid with the vapor of ether, by causing the patient to respire from a closed receiver containing the vapor, thus consuming his own breath until rendered insensible by its carbonic acid mingled with ether. This practice cannot be too strongly condemned.

Carbonic Disulphide, CS_2, *Bisulphide of carbon*. Sp. gr. 1.269. Boiling point, 47°.7 C. (117°.8 F.). A colorless, volatile liquid, with a pungent aromatic taste, and an agreeable odor when pure. It is formed by dropping pieces of sulphur upon red-hot coals in a retort. The general anæsthetic effects of the vapor resemble those produced by chloroform, but it also produces great depression, sometimes followed by coma. Workmen exposed to its fumes in certain factories experience great depression, weakness, and loss of memory. The liquid has been used externally with some degree of success for the relief of neuralgia; but the offensive odor if impurities are present, and the disagreeable effects of the resulting vapor, have led to its complete abandonment.

Note.—Additional statistics show 84 deaths in 492,235 chloroform inhalations, or one in 5860. (See p. 423.)

OPERATIVE SURGERY IN GENERAL.

BY

JOHN H. BRINTON, M.D.,

LECTURER ON OPERATIVE SURGERY IN THE JEFFERSON MEDICAL COLLEGE AND SURGEON TO THE JEFFERSON MEDICAL COLLEGE HOSPITAL, SURGEON TO THE PHILADELPHIA HOSPITAL, AND TO ST. JOSEPH'S HOSPITAL, PHILADELPHIA.

Submission to a surgical operation is at all times, and to every one, a formidable trial. It is not the pain alone which affrights, but it is the absolute self-surrender from which the patient shrinks, conjoined to the uncertainty which attends the issue of even the most trifling operation. An operation, therefore, should not be lightly undertaken, but should be well considered, and should only be resorted to in the interests of the patient's life or comfort. It has been the custom to speak of operative surgery as a mere *art*, and its achievements have been looked upon by some as detrimental to the *science* of surgery—"opprobria." This is, however, but a narrow view, for in the adaptation of surgical means to the ends desired, in the selection and preparation of cases, in the operation itself, in the after-treatment, in combating all evil influences, and in conducting the sufferer to a state of renewed health, surely Operative Surgery may justly share the honors of the "Science *and* the Art."

Qualifications of a Surgeon.

In all matters in life, the every-day test of excellence is success. So, too, the measure of the surgeon's abilities, in the long run, is his success. He may be never so brilliant an operator, yet, lacking other essential qualities, the record of his work may be against him. On the other hand, no man can be a good surgeon without manual dexterity, be his judgment and other acquirements what they may. The qualifications, therefore, of an operative surgeon appear to be varied and comprehensive.

In the first place, he must be thoroughly *honest;* he should operate only in the interests of his patient's highest good, where life is to be saved, or discomfort or deformity relieved; he ought never to be tempted even by importunity to perform an unnecessary operation; nor to operate for the sake of display, nor in the desire of acquiring notoriety or fame, nor for the sake of linking his name with this or that procedure. In doubt, he should try always to place himself, as it were, in the patient's place, and, before deciding upon an operation, at all times be able to answer distinctly and affirmatively the self-directed question—Is the proposed surgical interference really for my patient's good?

The surgeon should be *adroit*, and possessed of manual skill and dexterity. He must be a good workman, and his work must be thorough and exact. He should guard against precipitation, for in every mechanical art hasty work means bad work; and in operative surgery this is sure to be the case, and it is here that the old motto, "festina lente," so strongly applies. A hasty operator will often do too much, and yet leave undone something which may affect the issue of the case. Every operation must, therefore, be performed with deliberation and in an orderly manner. Each step ought to be well thought over and planned beforehand; and whilst there must be no undue haste, neither should there be unnecessary delay. The universal use of anæsthetics has long since removed from operations alike the necessity and temptation of hurry; at the same time, it has imposed upon the surgeon the duty of quiet, prompt procedure, in order that the patient may be released from the anæsthetic influence as soon as possible.

A *knowledge of anatomy* is essential to the operating surgeon. By some its importance has been decried, and it has been regarded as a stumbling-block, rather than an assistance, to the operator. For them, the old maxim of "cut and tie what bleeds" has been sufficient. But at the present day, in view of the frequent performance of operations of the most delicate nature, and of the invasion by the knife of regions once sacred and undisturbed, where the only safeguard is the surgeon's anatomical knowledge, it is useless to enter upon any discussion of this subject. It may then be assumed, not only that the surgeon should possess a knowledge of anatomy, but also that this information must be of a peculiar kind. The mere acquaintance with muscular origin and insertion, with the direction of vessels and nerves, and the like, is insufficient. The operating surgeon wishes, and the claims of his art demand, more than all this. His comprehension of anatomy must embrace the tissues in disease as well as in health. He must know them topographically, singly, and in groups and layers, and must be able to recognize them when transformed by morbid action. An *appreciation of tissues* is in fact one of the very highest and most practical of the accomplishments of the surgeon, and by this is meant the power to recognize the living tissues under all circumstances.

It seems, in truth, as if there were two varieties of anatomical knowledge: the knowledge of the anatomy of the dead subject—*cadaveric anatomy*—as seen by the pure anatomist; this is well enough in its way, and answers sufficiently as a basis for the other, to wit, a knowledge of *clinical anatomy*, which alone can serve the purposes of the surgeon—the anatomy of the living tissues. It is only this knowledge of applied anatomy which confers upon the educated and practised operator that skill which leads up to great successes. It is this alone that enables him to recognize tissues, however masked, or changed, or hidden. It is this which gives his hand dexterity, and almost endows his knife with vital consciousness. Without this power of discriminating tissues, the operations of the surgeon must be at best gropings in the dark; with it, on the other hand, they will be characterized by skill and certainty, by safety for his patient, and by satisfaction for himself. The acquisition of this knowledge of anatomy is no easy matter; it cannot be gathered from books, nor can it be arrived at to best advantage by the ordinary methods of dissection. It can only be learned by dissections practised by regions, and with a true surgical intent, and these must be repeated again and again; for, as Paré tells us in his chapter on "Chirurgicall Operations," "Thou shalt far more easily and happily attain to the knowledg of these things by long use and much exercise, than by much reading of Books, or daily hearing of Teachers. For speech, how perspicuous and elegant soever it be,

cannot so vively express anything, as that which is subjected to the faithfull eyes and hands."[1] This knowledge, once acquired, must be kept up by dissections repeated from time to time, and especially ought the surgeon to refresh his memory when about to venture upon any new or delicate procedure. Many blunders happen during an operation from a defective acquaintance with anatomy; none because the operator knows too much. Repeated practice upon the cadaver cannot be too heartily enjoined; and this will at all times prove of advantage to the surgeon, whatever his years may be, and however ripe his experience.

The *demeanor of the surgeon* is a matter of no little importance. On the eve of operation, his every look and movement are closely watched, and a patient will often derive much comfort from noting the composure of the surgeon, his coolness and evident self-reliance. In his manner he should be kind and sympathizing, dignified, and free from ill-placed levity. Above all things let him try to foster in his patient that faith and confidence in him, which go so far to soothe the spirit and strengthen the resolution of one about to place himself in the surgeon's hands. It is not, however, alone upon the patient and his friends, that the happy effect of the surgeon's mental composure is produced. It influences too his assistants and the lookers-on at the operation; and these are sometimes many, for the work of the operator is often done in public, where he stands in full view of critical eyes, and not unfrequently exposed to carping tongues. The surgeon ought not to present a mere outward composure; but in reality he should possess it. *Sangfroid*, intrepidity, and the power of self-support are absolutely essential to his success. His presence of mind should never desert him. He must train himself to think, during operation, of his work, and of his patient; and not of the bystanders. If things go wrong, he must preserve his coolness, and not suffer himself to fall into that condition of mind which has been described as "surgical delirium"—in which the operator loses his head, and strives to extricate himself from embarrassment by ill-directed and often aimless efforts.

For it must be here observed that, while the surgeon may, year after year, pass along with little seriously amiss in his operative practice, yet, sooner or later, trouble and accident may, and indeed must, come. Startling vicissitudes, catastrophes which can neither be anticipated nor prevented, are sure to happen. These are the incidents of human life, and the professional man who deals so largely with life itself cannot expect to escape them. It is impossible to conduct an active surgical practice for a long period without meeting with occurrences which Paget has justly called "surgical calamities;" with every care it is not possible to foresee such contingencies, and the surgeon must stand prepared to meet them as they come. Let him then train himself in habits of independent thought, action, and self-reliance. Let him stand strong in the best knowledge of his profession, and in the firm determination to act for his patients' good, and for that alone; then, if ever these dreaded calamities shall fall upon him, his shoulders will prove strong enough to bear them.

The success of the operation is undoubtedly influenced by manual dexterity in its performance, but beyond the mere mechanical skill are other factors. The proper *selection of cases*, due *preparation for the operation*, and careful *nursing*, *feeding*, and *after-treatment*, have very much to do with the welfare of the patient. Indeed it may be said that the exercise of a wise and sound judg-

[1] The works of that famous chirurgeon Ambrose Parey, translated out of Latin, and compared with the French by Th. Johnson. Book I., Chap. II. London, 1649.

ment, in these respects, bears greatly upon ultimate success or failure. It is the observance and enforcement of all precautions, before, during, and after an operation, which give the sufferer his best chances, and it must never be forgotten that the latter is entitled to *all* the chances which operative skill and the exercise of sound judgment can possibly afford. It is a mistake to look upon the failure of an operation simply as an untoward accident to the operator; we must recollect that there is another party to the transaction, the patient; and if harm befall him, either from deficient skill, lack of prudence, or too biased convictions on the part of his surgical attendant, surely there is matter of self-reproach for him in whom he trusted. If, on the other hand, the surgeon acts on full consideration of the facts attending each individual case, with a wide knowledge of the general practice of others, with proper reliance on his own experience, and an earnest seeking after his patient's good; then indeed he has done all that man can do, and may humbly await the issue from the hands of the Almighty Arbiter of all things human.

While it is incumbent upon the surgeon to do much that is merely manipulative in character, it must not be forgotten that, besides the operation, he must perform many duties which demand the exercise of the highest functions of the medical mind. He must be a good *diagnostician*, medical as well as surgical, and possess an accurate knowledge of morbid anatomy, and of general pathology. He must, above all things, exercise skill in searching for, and in detecting, *visceral disease*, for here a broad field has been opened to the view of the practical surgeon. In times past, it was perhaps too much his custom to confine his study to that only which was evident to the eyes and touch. He did not trouble himself greatly with those morbid processes which were developing in organs, it might be somewhat removed from the local seat of disease, but which were often related to or influenced by the proposed operation. Pathology has, however, made fast onward strides, and no operation can now be undertaken without a careful examination of the internal organs; since the presence of lurking visceral disease, often unsuspected, may forbid or modify surgical interference. The surgeon must moreover be a good *therapeutist*, and an expert *clinical observer*—ever prompt to catch the passing indication, ever ready to interfere on just occasion, or, with wise caution, patient to hold his hand. He should be sharp-witted in emergencies, and quick in his decisions; for the tide of surgical accident runs fast, and if he falter or delay, precious moments may be forever lost. In short, the surgeon should be an Accomplished Physician as well as a Skilful Operator, possessing a comprehensive knowledge of diagnosis, pathology, and therapeutics; with less he can neither do justice to his patient, nor satisfy the demands of his own conscience.

Preparation for an Operation.

A certain amount of risk to life accompanies all surgical interference. It is present in a marked degree in serious operations, and is not absent from those of apparently the most trifling character. Death may and has followed the simple introduction of a sound, the slitting of a contracted meatus, or the ligation of an apparently insignificant pile. It is, therefore, fit that the surgeon before operating should bear in mind the possibility of an untoward result, and that he should seek by every means in his power to guard his patient against unfavorable chances. His wisdom and judgment will be never more apparent than in the care and skill he may exercise in preparing the patient for operation. Each case should be to him a study, and he ought

carefully to investigate its characters. His conclusions should be deliberately arrived at, and the propriety of an operation must be quite clear to his own mind, before any announcement is made of its necessity. When, however, it is evident to the surgeon that an operation should be done, it becomes his duty to state the facts to the patient, if he is of sufficient age, and in a proper state of mind, or, if not, to his family or friends. This should be done gently, and not abruptly, nor in a manner calculated to alarm. The necessity of the operation ought to be clearly explained to those concerned, and the chances of success and recovery fairly laid before them.

It is also right that the surgeon should add to these statements the weight of his professional opinion, and he must not shrink from the responsibility of so doing, nor speak with hesitation or doubt. He must remember that the persons interested look to him for advice, and that as consultants they are fairly entitled to whatever help he can so render them. It is not to be expected that the public can always decide wisely in matters affecting life or health; they must in the end depend upon professional judgment; and the professional utterance ought to be positive and unmistakable. It becomes, therefore, the duty of the surgeon to neither exaggerate nor underrate the possible peril of an operation; he must think for his patient, and by his sympathy and the kindness of his manner win the confidence of the latter, so making him to feel that the arm of his surgical adviser is in truth one of strength, upon which he, in his own weakness, may safely lean. All this the surgeon may rightly do, not endangering his professional position, but rather strengthening it by his services as counsellor and friend. To the question which is so often put in minor cases, "Is there any danger in the operation?" he can truthfully answer, "Not greater than in the chapter of the ordinary accidents of life, and whatever risk there is, I advise you to take it." The ultimate decision thus rests with the patient himself, but he may be fortified in mind, and upheld in a correct judgment, by the judicious and wise words of his professional attendant.

In a general way, it is customary to divide surgical operations into two great classes. The first comprises *operations of necessity*, where life is at stake, and where surgical interference to be of avail must be immediate. Operations for strangulated hernia, or for hemorrhage, or for foreign bodies in the air passages, or for many surgical injuries, are examples of this nature. The second class comprises *operations of expediency*, in which a slight delay in performance does not materially affect the result. The removal of morbid growths, the correction of deformities, and many other operations in the great category of surgical diseases, are examples of the second order. In deciding upon operations of the first class, the surgeon must often assume a great responsibility. His professional duty demands that he should act decisively and promptly to save life; and, in the absence of friends, or where the patient is very young, or from the very nature of the case incapable of being consulted, the surgical attendant must take the burden upon his own shoulders. Sometimes, in such capital cases, the advice of colleagues may be obtained, but where the urgency is very great, the surgeon should learn to depend fearlessly upon his own judgment, and to act in accordance with it.

Time for Operation.—In ordinary cases, not those of immediate necessity, where an operation has been decided upon, the first question which presents itself to the mind is the time for its performance. Broadly stated, the answer to this question is, "As soon as the patient can be brought into the best state of mind and body." The first of these conditions must depend somewhat upon the patient's *morale* and his confidence in his surgeon. Many sufferers

are nervous and timid; they dread the future, and shudder at the thought of an operation. Delay in these cases often makes matters worse; the mind reacts upon the body; and, for them, the sooner an operation can be performed with safety the better. Other patients may be less fearful of results, and may seem to be stoical, almost indifferent. These not unfrequently ask time for consideration, and, having reflected, come calmly to a decision, and place themselves in the hands of the surgeon with quiet confidence and bravery.

Preparation of Patient.—The general bodily health of one who is to undergo an operation must always be most carefully looked to, and all precautions taken to bring it into the best possible condition. Every operation, no matter how slight it may be, presupposes some extra strain upon the constitutional powers, and the resources of our art should be taxed to meet this demand. Unfortunately, it often happens that the very occasion for surgical interference is in itself a cause of impairment of vital strength, and unnecessary delay in operation is therefore to be deprecated. In hospital practice this is especially the case. Patients enter the wards with impaired nutrition, enfeebled by pain and suffering, and exhausted by chronic suppuration. The effort to improve their general state seems to be a laudable one; but even here mistakes may be committed; for it is undoubtedly true that too prolonged a residence in hospital is often productive of injury rather than of benefit to the patient. For the first week or ten days, he may seem to improve, but it is a matter of common experience that after that period much change for the better is, as a rule, scarcely to be looked for. It would seem therefore wise, in such cases, not to defer unduly an inevitable operation, but to proceed to its performance, in the absence of positive contra-indications, as soon as the secretions have been brought into tolerable condition. The removal of a source of irritation, or of a drain upon the constitution, will often do more to bring up a patient than any prolonged course either of dietetics or of therapeutics, and that this is true, is amply shown by the success which proverbially follows secondary operations.

Rest.—The influence of rest of mind and body, in fitting the latter to pass safely through the perils of an operation, must not be overlooked. The quiet of a day or so in bed permits the patient to recover from the fatigues of his daily work, and to obtain that necessary sleep which has sometimes been curtailed by the exigencies of labor. Overworked organs, and notably the heart, pass into a condition of repose; excited or perverted functions are soothed or corrected; local congestions are relieved; and, in short, body and mind are alike benefited by the state of true physiological rest thus brought about. Pain, which may have been aggravated by locomotion, becomes less, or disappears; and the patient acquires that custom or ability to remain tranquilly in bed which may become essential to his future welfare. Nothing is more detrimental to the success of an operation than after-restlessness and jactitation, and the exercise of patience, and practice in remaining still in bed, is a matter of more importance than it is usually considered. During this period of rest, too, the medical attendant has ample opportunity for familiarizing himself with his patient, and for acquiring that knowledge of him which may have a direct bearing on the after-treatment. He is enabled also to judge of his constitutional condition, by repeated physical examinations, and to form that correct estimate of his strength or weakness which may prove of so much value in the future conduct of the case. It is a matter of everyday observation that where operations are hurriedly undertaken, without due investigation of the patient's condition, they are apt to be attended by perils which might have been avoided by more careful examination. The writer can recall case upon

case, where the happy results of serious operations have been attributed to mere skill at the time of performance, when in truth they were not a little due to the previous painstaking and repeated examinations of the patient, and to the careful and watchful study of his idiosyncrasies.

Preliminary Treatment.—Deferring for a moment the subjects of the risks of operations, and the causes influencing their results, it may be well to inquire what preliminary steps must be taken to put the patient in the best condition for the operation, when the latter is imperative, or when it has been decided upon as judicious. If the operation be one of emergency, such as herniotomy, or tracheotomy for urgent cause, preparation in a general way can scarcely be attempted. The surgeon must do his best to save life already endangered, and the patient must take his chances, such as they are. On the other hand, if the case be one of a chronic nature, certain useful precautions before operation may be attempted. If the patient is in poor condition, and if time admits, the requisite diet, stimulus, and tonics may be employed, and the rest already referred to enjoined. The secretions may be attended to, and the bowels regulated as demanded. All previous medication, which may be inappropriate to the time of operation, should be stopped; and a sufficient interval allowed for the elimination from the system of such drugs as digitalis, arsenic, the iodide of potassium, and the like. If the case is one of injury demanding amputation, and the patient has not yet reacted, the bleeding should be controlled, and such stimulus administered as will bring about reaction, and release the sufferer from the state of shock.

The advisability of administering stimulus just before operation is a question which has been much discussed, and on which different opinions are now entertained. By some, a parallelism has been affirmed between the effects of alcoholic stimulus and those of the anæsthetic, especially sulphuric ether; both being regarded as agents which secondarily depress the action of the heart. Yet it is probable that the great majority of practical surgeons look favorably upon the administration of whiskey a short time prior to operation, especially if with the stimulus a small amount of opium is administered, either by the mouth or hypodermically. Clinically speaking, this conjoined exhibition of alcohol and opium is probably judicious, since it would seem to exercise a triple influence: In the first place it appears to lessen the shock of operation; in the second it tranquillizes the patient after the operation, and prevents or soothes the subsequent pain; and in the third place it expedites anæsthesia, and lessens the amount of ether necessary to be given. The testimony of many excellent surgeons seems to be conclusive in this direction, and in such a matter mere theoretical opinions cannot have weight when opposed to the direct results of clinical experience. In administering stimulus, care should be taken to give it three-quarters of an hour or an hour before operation. If given later than this, it may cause nausea and vomiting as the inhalation of the anæsthetic progresses—always an annoying complication, and peculiarly so at the beginning of an operation.

Anæsthesia.

It would be out of place in this article to enter upon the history of surgical anæsthesia, or to discuss the priority of claim of those with whom it originated. It is sufficient to say that its discovery originated in Hartford, Connecticut, in 1844, and that its first practical application for surgical purposes was made in Boston about the year 1846—the agent then employed being sulphuric ether. In the following year the anæsthetic qualities of chloroform

were announced by Professor Simpson, of Edinburgh. Since that time, the value of these two agents has been universally recognized. Throughout Europe, until quite recently, chloroform has been preferred by surgeons; while in America the professional mind has been greatly divided as to the relative value of the two agents. In the northern portion of the country, ether is probably the favorite agent, while in the south and west the predilection is in favor of chloroform. The merits of the rival agents may be thus briefly summed up: Both produce complete anæsthesia, but ether is undoubtedly the safer agent. It is, however, far more bulky, and consequently more difficult of transportation. It is, therefore, not so well adapted as chloroform for use in military or country practice. It is slower in its action, and more disagreeable than chloroform; and its use is attended by more struggling and rebellion on the part of the patient. The stimulating action of ether is felt largely by the nervous and respiratory systems, and on the latter it sometimes produces much irritation. The action of the heart is also stimulated by ether, and in this respect it differs from chloroform, which is apt to cause cardiac sedation. It seems, therefore, that the use of ether as an anæsthetic is indicated in cases attended by nervous shock, and also where there is cardiac weakness, the result of fatty changes or of ventricular dilatation.

COMPARISON OF ETHER WITH CHLOROFORM.—The primary excitant effects of *ether* are shortly followed by secondary sedation. This is at times aggravated by the tendency to nausea and vomiting, which occasionally is persistent, and which it is not always easy to check. *Chloroform*, on the other hand, is free from most of these objections. Its odor is agreeable, and its first effects sedative; it acts promptly, and, as a rule, without causing that degree of excitation and muscular action which is so characteristic of ether. It probably causes less nausea and gastric irritation, and it acts kindly and safely upon children. The great matter, however, in the choice of an anæsthetic is that of safety, and the one question to be answered is simply this: Which carries with it the least peril to the life of the patient, ether or chloroform?—and here it must be stated that the condition of anæsthesia is always one of some danger, and that no anæsthetic is altogether safe. A patient in a condition of absolute anæsthetic unconsciousness, is necessarily in more or less jeopardy of life, and it is incumbent upon the operating surgeon never to lose sight of this fact. It is to be feared that the comparative impunity which has attended the long-continued use of anæsthetics, tends to beget in the mind of the surgeon too great a confidence in their safety, and that he sometimes realizes only when it is too late that this blind confidence may be unfounded. Especially is this the case when the exhibition of the anæsthetic is submitted to unskilled hands, and that this is very often done it is impossible to deny. In reality, the assistant who has charge of the ether or chloroform, plays a part in the operation scarcely secondary to that of the surgeon himself, for on his skill, watchfulness, and judgment, the welfare of the patient to a great extend depends. It is, therefore, incumbent upon the operator to devolve this important duty only upon one who is qualified to undertake it; and the assistant himself must devote his whole mind to this given task. He ought to do nothing else, and should not permit his attention to wander for a moment from the patient before him, nor attempt to render any other assistance in the operation than that to which he is particularly assigned. He must carefully watch the breathing of the patient, and moderate or suspend the anæsthetic on the slightest evidence of its irregularity. He should be on the watch against retraction of the tongue, and, if this happens, he must instantly draw it forward with a hook or forceps, and see to the removal of mucus from the mouth or fauces. Not unfrequently, spasm and closure of

the larynx occur, evinced by the lividity and discoloration of the lips and ears. This can usually be relieved by turning the head, or by pushing forwards the angles of the jaws, and by making pressure upon the chest, thus exciting afresh the respiratory efforts. The pulse must be watched as well as the breathing, especially if the patient have a fatty heart, or any other form of organic cardiac disease.

While, in the great majority of cases, ether will accomplish all that chloroform can do, and indeed all that can be desired, and, as we think, with a greater degree of safety, there are nevertheless instances in which it seems proper to employ chloroform. As is well known, ether vapor acts as an irritant to the lungs even when healthy, and its use is sometimes followed by more or less bronchitis. It should not, therefore, be resorted to when any pulmonary irritation or inflammation already exists, but preference should be given to chloroform. Acute œdema of the lungs, terminating fatally in a few hours, has occurred after the inhalation of ether to the writer's knowledge, and it is probable that most of the few deaths charged to the use of ether have in reality been due to this cause. An examination of the lungs and of the heart must consequently be made before ether is given. The use of ether in cardiac disease has also been questioned, but here hesitation need only be felt when there is a tendency to overloading of the right heart; and there does not appear to be any reason for not giving ether when the heart is weak or fatty. Indeed, its action as a cardiac stimulant would rather favor its employment in these cases, but under such circumstances its effects must of course be carefully watched. Chloroform is peculiarly adapted for children; upon them it acts readily, and, as far as is known, safely.

First Insensibility from Ether.—Before describing the mode of administration of ether and chloroform, it may be well to allude here to one of the effects of ether inhalation which is not as widely known as it deserves to be, namely, the transitory state of first insensibility produced by a few whiffs of ether, originally pointed out by Dr. Packard, of Philadelphia,[1] who has noticed that, if, when a patient begins to inhale ether,

> ". . . . he be told to hold up his hand, and the direction be repeated as often as necessary, for a little while he will obey, but soon there will be a failure of voluntary power, and the hand will drop. At this instant there begins a very brief period—less than a minute—of total insensibility. If the inhalation be now suspended, consciousness will return at once, and the patient will come to himself without headache, nausea, or any other of the disagreeable effects so commonly experienced after the prolonged administration of the anæsthetic. During this brief period of anæsthesia, the 'first insensibility,' as I have called it, any operation may be performed as painlessly as if the inhalation had been carried to the fullest extent. . . . . I feel warranted in asserting that this first insensibility invariably occurs; that it is absolute and profound, though brief; and that it may always be detected and taken advantage of by careful observation and prompt action."

From a personal experience, the writer can testify to the entire accuracy of Dr. Packard's statements, not only as to the occurrence of this short insensibility, but also as to its thoroughness and completeness as regards any sensation of pain from cutting operations.

Administration of Ether.—In obtaining anæsthesia from ether, not a little depends upon the skill of the administrator. If the patient be frightened or roughly handled, he naturally rebels, and the process is necessarily prolonged, and therefore to a degree imperfect. Here, as in all other surgical

[1] American Journal of the Medical Sciences, July, 1877, and April, 1878.

procedures, the first step should be to win the confidence of the patient, and to impress him by gentleness rather than by force. In the early days of ether, various complicated forms of apparatus and mouth-pieces were constructed to assist the inhalation. In America these have given way to methods of greater simplicity—the employment of the folded towel or the sponge. Perhaps the simplest plan is the use of a towel folded and pinned in the shape of a cone; the sides of the cone may be stiffened by placing within the folds of the towel a layer or two of newspaper. A chamber is thus formed for the retention of the ether vapor, the base of the cone being sufficiently large to thoroughly cover the mouth and nostrils, and to include the lower jaw. The eyes of the patient should be covered with a light napkin or handkerchief at the beginning of the inhalation. This precaution shuts out the observation of external circumstances, and has a very marked effect in hastening the period of insensibility. It is well also to divert the attention of the patient by directing him to count slowly "one, two, three," and so on, following the lead of the administrator. The expiratory effort thus induced is followed by a corresponding inspiration, and full inhalation of the ether is thus greatly favored. Few persons can count as high as twenty-five or thirty without feeling the effect of the agent, and scarcely any can reach sixty or seventy without becoming unconscious. The best test of the proper period for operation having arrived is insensibility of the eyeball and general muscular relaxation. The ether can then be withheld or pushed, as the circumstances of the case may indicate. The unconscious occupation of the mind by the counting method will be found preferable to the usual coaxing attempts, or the futile advice to the patient that he should try and go to sleep, which is commonly under the circumstances very difficult for him to accomplish. Ether can also be administered from the folds of a towel without the formation of the cone described. This is not so perfect a method, lacking, as it does, the formation of a true ether atmosphere, and is accompanied by more resistance and struggling of the patient; nor does it seem to possess any of the advantages of the method already described.

When the patient is inclined to resist, or takes ether badly, the resistance can usually be overcome, if the exhibition of the vapor be begun slowly, and if the cone, towel, or other vehicle, be gradually brought nearer to the face, as he becomes accustomed to the ether odor. The patient should always be placed in the recumbent posture before etherization is commenced; it is a mistake, not unaccompanied by risk, to attempt anæsthesia in the sitting or semi-recumbent posture. Of course, all constraint of clothing should be removed from the neck and waist, and false teeth should be taken out, as they are liable to become displaced; and instances have occurred in which they have been swallowed during insensibility. If any operation is to be attempted within the mouth, involving the separation or holding apart of the jaws by corks or like substances, the latter should be controlled externally by strings. An instance occurred not many years since in Philadelphia, in which a cork used as a gag was drawn into the larynx by violent inspiration, producing an immediately fatal result.

In using ether it is well to watch the pulse carefully as well as the breathing. If the pulse is good, the patient is doing well. If it becomes feeble or infrequent, the ether should be withdrawn and the access of air permitted. So also if the lividity of the face increases, or if laryngeal spasm occurs, more air must be given. When mucus collects in the mouth and fauces, and there is usually a good deal, it must be removed; and if from any cause the breathing seems to be interfered with, or deficient, access of air must be allowed by opening the mouth or drawing the cheek out, and seeing that the tongue is not retracted. Vomiting when it occurs should be met by turning the head

to one side, so that the mouth may be dependent, when the vomited matters may easily be gotten rid of.

In using ether at night, care should be taken to keep the lights above the level of the patient's body, so as to prevent ignition, the ether vapor being heavier than air. So also in operations demanding the application of the actual cautery, the possible ignition of the ether vapor should be carefully guarded against. By practical experience, it has been shown that this accident may be prevented by fanning the air in front of the patient's mouth for a moment or so before the approach of the hot iron. Nevertheless, the utmost care in this respect must be observed. The same remarks apply to the careless use or too great proximity of the spray-producer in Lister's method, which has also on more than one occasion set fire to the ether. Indeed, it may be questioned whether, in operations where ether is employed, the steam atomizer should be used at all, unless in those upon the trunk or extremities. The powerful atomizer arranged by Dr. J. Solis-Cohen is free from this objection, since in it the spray is produced under atmospheric pressure, without the employment of a flame.

The exhibition of ether by means of a large sponge, once so universally adopted, is not now generally resorted to. It accomplishes the purpose well enough, but is attended by wasteful expenditure of the anæsthetic, and by too great an impregnation of the air of the room.

The amount of ether which it is proper to use in an operation, of course varies greatly. When it is judiciously administered, when its effects are carefully watched, and when its exhibition is relaxed from time to time upon the appearance of too marked a lividity of face, its influence may be continued for a very considerable time. In the treatment of a subclavian aneurism by compression exerted by a tourniquet, to the extent of cutting off all arterial impulse, the writer has, on several occasions, kept the patient well etherized for six, seven, or eight hours at a time. But it must be remembered that no anæsthesia is altogether safe, and the risks in such a case must be deliberately weighed against the possible advantages to be gained. Occasionally patients are met with who seem to have an intermittent respiration, with a tendency to lividity. With such persons extraordinary care must be used in the administration of an anæsthetic, and atmospheric air must be freely admitted.

After-treatment of Ether Anæsthesia.—A matter not to be overlooked in the use of anæsthetics, ether as well as chloroform, is the after-care. A patient should not be left by himself, or unwatched, until he has regained his consciousness, or until the respiration, circulation, and color of the skin have been fairly established. Very frequently, anæsthesia is followed, particularly in children, by prolonged sleep, but the surgeon will feel more comfortable in his own mind if the patient has once fairly reacted into consciousness, before being allowed to pass into slumber. Sponging the face with cold water, or slapping the face and chest gently with a wet towel, will usually bring the patient to himself, and when once he has been sufficiently aroused to answer questions put to him, immediate danger may be regarded as having passed away. In etherization, however, there is always the possibility of the subsequent pulmonary complications already alluded to, and it is difficult to say what precautions can be adopted to prevent the development of the acute œdema of the lungs, which, once established, is usually so destructive to the patient. Fortunately, however, looking at the vast number of cases in which ether is given, with an almost absolute impunity, this accident is very rare; yet it is still a contingency which may occur. In cases in which prolonged etherization is necessary, Dr. John Ashhurst directs the subsequent administration of carbonate of ammonium in doses of five grains every half hour,

hour, or two hours, according to circumstances, until all risk of pulmonary congestion and œdema has passed away.

There is one other untoward effect of etherization, which is sometimes met with, and which does not appear as yet to have been fully studied. It is the suppression of urine, and uræmic poisoning, met with in cases where disease of the kidney has been pre-existent. To what extent this condition is chargeable to the ether used, or whether it is rather the result of the operation itself, is not altogether clear. It is nevertheless probable, that prolonged anæsthesia, or perhaps we should say etherization, may interfere with the due elimination of the urinary constituents. A proper examination of the urine should, of course, be made before any serious operation is attempted, and, if organic disease of the kidney be manifest, the operation if done at all should be accompanied by as short a duration of anæsthesia as is consistent with the circumstances of the case.

Administration of Chloroform.—In Europe, and in a large section of America, and in the military and naval services of different countries, chloroform is the favorite anæsthetic agent. In the late civil war in this country, it was employed by both combatants almost to the exclusion of ether in armies in the field, and in very many of the large hospitals in the rear. The convenience, portability, prompt action, and pleasant effects of chloroform are everywhere admitted, and have already been referred to. It remains to consider its danger; and that it is dangerous is conceded by all, even by those who are loudest in its praise. Very many excellent surgeons can be found who have used chloroform for years, without an accident, and who have never witnessed an accident at the hands of others from its employment. Yet the surgical mind is undoubtedly being influenced by the growing death-roll which has marked its use. In Great Britain especially, where chloroform has for so many years been the favorite anæsthetic, a distrust of the agent is springing up, and the employment of sulphuric ether is becoming daily extended. The pages of the medical press evince this altered opinion most distinctly, and that it is a judgment based upon conviction, no one can doubt who is conversant with the honesty, good faith, and wide experience of the British medical profession.

The administration of chloroform by surgeons in this country, and probably by the major portion of those who use it abroad, is effected by pouring a drachm of the drug upon a piece of lint, or a folded towel of two or three thicknesses. This is at first held three or four inches from the face of the patient, and gradually approximated until within an inch of the nose. Free circulation and admixture of air with the chloroform are thus permitted. The defect of this mode of administration, as stated by Mr. Erichsen, is that there is no possibility of estimating the true proportion of the admixture of air and chloroform, and that the administrator can only judge by his observation of the resulting effects. To remedy this uncertainty, various inhaling apparatuses have been designed, the best of these, to quote the same authority, being those of Messrs. Shaw and Clover. In that of the latter, the mixture of 30 to 40 minims of chloroform with 1000 cubic inches of air is ingeniously accomplished, and from a bag charged with this mixture, the inhalation by the patient is effected through a tube and mouth-piece.

The first effect of chloroform is an excitant one upon the nervous system, and upon the action of the heart. This is soon followed by motor and sensory paralysis, by insensibility, and by a sedative effect upon the heart, with feeble respiration, and a state of greater or less asphyxia. At this time, if the chloroform be unduly pressed, there is danger of death resulting.

The occurrence of stertorous breathing indicates that the administration ot the chloroform should cease.

The exhibition of chloroform is often followed by effects of an annoying character. Thus gastric irritability, accompanied by nausea and vomiting, may supervene; this does not happen as often as after the inhalation of ether, but, when it does occur, it is apt to be severe and depressing. Slight congestion of the lungs is also met with, as in the case of ether administration, but it is not so common, nor, as a rule, so irritating. Cephalic troubles also occasionally take place. The evil effects of chloroform are, however, not to be found so much in its secondary consequences, as in the liability to death at the time of administration, or during or after an operation. When death thus occurs, it is usually immediate, and cannot be prevented; and it may be charged either to asphyxia, to coma, or to syncope. It has taken place not unfrequently in those who seemed to be the most healthy, and after the performance of the slightest operations and surgical procedures, such as the amputation of a finger or the passage of a catheter. It is impossible from any previous examination to predicate with certainty the chances of danger, and it would seem also equally difficult to treat them when once fairly developed. As we have already said, in all anæsthesia there is some danger, and in the anæsthesia from chloroform the chances of danger are greater than those attendant upon the use of its rival—ether.

Should it unfortunately happen, during the administration of chloroform, that any of the dangers referred to are present or threatening, the most active measures must be adopted to check them or ward them off. The chloroform should be immediately withdrawn; fresh air admitted; cold water dashed upon the face; the tongue, if retracted, drawn forward; and prompt efforts at artificial respiration instituted. If the effect of the drug fall chiefly on the heart, as evinced by the state of syncope, its action should be stimulated by electro-galvanism, the poles of the apparatus being applied on the chest and diaphragm and over the spine. Mr. Erichsen, in his valuable remarks on this subject, speaks of the use of nitrite of amyl, referring to the experiments of Dabney. From what I have seen of the effect of this drug as an antidote to an overdose of bromide of ethyl, an agent which is certainly as sudden and fearful in its action as chloroform, and probably much more so, it would seem that the nitrite of amyl exercised a most powerful influence in raising the patient from a condition of syncope or asphyxia, and in establishing reaction. The quantity employed in the cases referred to was twenty or twenty-five drops, and its action was immediate.

Local Anæsthesia, the result of extreme cold produced by different methods, may sometimes be advantageously employed in slight operations, such as the opening of abscesses or the removal of a toe-nail. It is, however, not applicable to operations in which deep tissues are divided, but is limited to skin-deep incisions only. It can be conveniently brought about by the application of a piece of ice on which a little common salt has been sprinkled, covered by a single layer of a towel, and kept steadily upon the part for three minutes. It can also be obtained more perfectly by the spray of pure ether, or by that of rhigolene. The latter will freeze the tissues to some depth, but perfect congelation, at times, renders it difficult to distinguish, during operation, abnormal from healthy tissues. This excessive freezing is also sometimes followed by too great a reaction, and by sloughing. For these minor operations, when merely a temporary and, as it were, local insensibility is desired, the transitory effects of the inhalation of ether already described may be preferably substituted.

Other Means of Producing Anæsthesia.—Allusion has already been made to the use of the vapor of *bromide of ethyl* as an anæsthetic agent. Its properties in this respect were first demonstrated by Mr. Nunnely, of Leeds, who, in 1865, used it in surgical operations. The difficulty of its preparation and its great cost led, however, to its abandonment, especially as at that time it did not appear to possess any qualities which rendered its employment more advantageous than that of other substances. In 1879, its use was revived by Drs. Levis and Turnbull in Philadelphia, and a wide application of its powers was speedily made. At a first view, it seemed that the long-desired anæsthetic had at last been found in an agent which was not disagreeable to inhale, which produced anæsthesia with great promptness and without much nausea or vomiting, and from the effects of which the patient recovered as rapidly as he had passed under them. More extended observation, however, showed that the employment of the new agent was fraught with danger, and that its seductive qualities were more than counterbalanced by their attendant perils. Its exhibition was marked by rapidly developed anæsthesia, accompanied by much muscular rigidity and spasm, apparently of a tetanic character, and, at times, reaching almost to opisthotonos. While in the great majority of cases patients did well, still, instances occurred in which they were rescued from the combined condition of coma and asphyxia only by the most active measures, including the use of the nitrite of amyl. Excellent and powerful as the agent was in many respects, its continued use seemed to be undesirable on account of the certain peril which attended it. Its employment has, therefore, been abandoned, and, as we think, wisely.

The employment, under the name of *chloric ether*, of a mixture of ether and chloroform, has been strongly advocated by many surgeons. It has been stated that, by the admixture of one part of chloroform to five of ether by weight, a compound agent is obtained which combines the advantages of ether and chloroform, and is yet free from the objections to both—the stimulating effects of the former counteracting the depressing influences of the latter. By some the proportion of chloroform in the mixture is greatly increased. There is no doubt that "chloric ether" acts promptly and efficiently, but it is questionable whether the dangers incident to chloroform do not still exist, since it is probable that the chloroform acts in its characteristic manner, unchanged by its combination, or rather mixture, with ether. From a prolonged experience with this compound agent, the writer believes that the alleged immunity to danger is not obtained, and that the chloroform still exerts its effects as chloroform *per se*.

Nitrous oxide is occasionally employed as an anæsthetic. Its use is, however, greatly restricted by its transitory effects, and by the rapidity with which the patient emerges from its influence. It is only suitable for the slightest operations, and possesses no advantages over ether employed as already described.

Mode of Conducting an Operation.

In the *performance of the operation* itself, the skill, readiness, and self-command of the surgeon are tested to the utmost. He should always be master of the situation, and should stand prepared for every emergency. Order must characterize all his arrangements, and every step must be well considered beforehand, and executed with promptness—free from hesitation, and yet devoid of all appearance of haste. The same deliberation should characterize the final as the initial steps of the operation. Sir James Paget, in his admirable chapter on the "Calamities of Surgery," has so vividly portrayed that

condition of mind which every operator must have felt towards the close of a serious operation, that his words deserve to be indelibly imprinted on the mind of the surgeon. He says:—

"Be quite clear about carrying out carefully the last stages of all operations. I suspect that everybody in operating, when he has passed through the sort of mental tension in which he performs the most difficult part of what he has to do, when his attention has been completely occupied in some difficult task to be achieved, next feels his mind relaxed, his attention less keen, less ready for exercise than it was before. Be sure that these are times of danger to your patient; as soon as the attention ceases to be as keen as possible, you are in risk of doing some mischief."

Few operations can be performed by the surgeon alone. In most cases he requires professional aid, and this should be rendered by *trained assistants*, accustomed to operations, and, if possible, in the habit of assisting the individual operator. These gentlemen should be efficient but not officious. Their duties should be assigned to them by the surgeon himself, and should be performed by them in perfect quiet, and in a manner calculated to assist and not to embarrass the operator. An able assistant is of the greatest use, while an inefficient one is only a source of annoyance to his principal. The *time* most suitable for operation is near the middle of the day, as the light is then at its best. Care should be taken that the patient's breakfast has been a simple one, and that his stomach is not overloaded when the period for operation has arrived.

For most operations the patient should be in the *recumbent posture*, as loss of blood is then more readily borne, anæsthesia can be best effected, and there is much less chance of syncope. He should be placed on a table of proper height, and one can usually be formed by utilizing articles of room furniture, such as two small tables, or a table and washstand, and then covering them with blankets. The improvised table can then be brought near to a window, and in full light. Attention to the matter of the operating table is of more consequence than is usually supposed; for it enables the surgeon to discharge his duties in comfort to himself, and without that strain and weariness in the back which is invariably felt when the operator is obliged to bend down in a constrained position over a low bed. Attention at the same time must be paid to the patient's comfort, or rather to his well-being, while on the table and under the anæsthetic. He ought not to be unnecessarily exposed to the air, but should be kept warm. The trunk and the lower extremities must be carefully covered, since there is always, during an operation, a tendency to a decrease in the temperature of the body. In operations upon the urinary and genital organs, when the lower part of the body must be uncovered to a certain extent, the legs of a pair of drawers, divided in the crotch, can be drawn over the lower limbs. If laxity be permitted in this respect, and the temperature of the body be allowed to fall unduly, an additional element of shock is created. Too much precaution cannot be exerted in this matter, particularly in the case of delicate persons, women, and children.

The *immediate dangers of operation* are hemorrhage and shock. The former must be prevented by every possible means, as the loss of an extra ounce or so of blood is often the turning point in a case. In children particularly it should be guarded against, since they bear bleeding very badly. Fortunately, in Esmarch's elastic bandage we have a means of practising many serious operations without the loss of blood. A new department of surgery has thus been created—bloodless surgery—which is applicable not only to amputations, but indeed to all operations upon the extremities. It is scarcely necessary to describe the apparatus here. As is well known, it consists of two elastic bandages, one of which is wound around the limb from its distal extremity to

above the point of operation, thus expelling the blood from the part, and leaving the tissues completely exsanguine. The second rubber band, thicker and stronger than the former, is then carried two or three times around the part, with sufficient tension to thoroughly compress the soft tissues, and cut off the circulation in the arterial trunks. The first band is then removed, when the operation can be performed without bleeding, and with the same facility as on the limb of a cadaver. In applying the second constricting band, care must be taken not to draw it too tightly; if this be done, there will be danger of sloughing; this is not an imaginary evil, but has occurred, and the resulting ulcers have been deep, unmanageable, and difficult to heal. The broad thick band is preferable to the tubing, which has been so much used, since the latter on being stretched acts as a cord, and is apt to produce mischief. If the reader doubts this assertion, let him try the experiment of the application of these rubbers upon his own person, and he will be quickly convinced of the power of their action. There is another precaution which it is well to observe in the use of the upper constricting band; this is, not to apply it when the muscles and tissues which it constricts are in a state of shortening or flexion. If this mistake be made, and the distal portion of the limb be afterwards extended, as may be necessary during an amputation, injury or laceration of the upper structures may take place, thus causing troublesome after-consequences, or even deep sloughing. A question has arisen as to the propriety of making much pressure, with the first bandage of Esmarch, over suppurating or gangrenous tissues, or even malignant growths, and it has been urged that, by so doing, disorganized and morbid elements might be forced into the general circulation. Whether this be so or not, it is difficult to say; at the same time, it is a contingency which it is worth while for surgeons to bear in mind.

A plan of emptying a limb of blood by simply elevating it to the highest point, and then stroking it for a minute or more in the direction of the venous circulation, has of late years been practised in Great Britain, and is described by Mr. Erichsen as "Lister's method." It is one, however, which has long been familiar to the American profession, and was witnessed by the writer in the hands of Pancoast of Philadelphia, nearly thirty years since.

Before beginning an operation, the surgeon should see that the *proper instruments* have been laid out, and that they are in good condition, and, if he intends to employ complicated apparatus, that it is in working order. Neglect of this precaution is often attended with great annoyance, and these matters should not be entrusted to an assistant, but should pass beneath the surgeon's own eye. If the operation be a cutting one, all *incisions* must be deliberately planned, and made without faltering. Haste should be avoided, but each stroke of the knife should be an onward step in the operation, and piecemeal or imperfect work ought not to be permitted. The first cut should divide the entire thickness of the skin, and the succeeding one, if the operation be a deep one, as the ligature of an artery, should be of the same length. The division of the deep structures will thus be as long, or nearly so, as the first incision, and full opportunity will be afforded the operator to make the necessary search at the bottom of the wound. When this course is not followed, the lowest portion of the wound will often be so contracted as to prevent full examination. The wound will in fact be a cone, with the apex downwards, a most undesirable result. In making dissections and incisions, if the bloodless method is not adopted, it is well to tie the larger vessels as they bleed, while the smaller ones can be left until the conclusion of the operation. For the *ligature* of vessels, the ordinary silk or linen thread, or the carbolized cat-gut ligatures, may be employed. *Acupressure pins* may at times be conveniently substituted for the ligatures, not only for the purpose of con-

trolling existing hemorrhage, but also for preventing it in regions where Esmarch's bandages are not applicable. Thus if a pin be passed beneath the facial artery as it mounts over the lower jawbone, plastic procedures may be readily practised on the face with little loss of blood; and in the same manner, operations around the mouth and lips may be greatly facilitated by judiciously transfixing the adjacent tissues with acupressure needles, around which strong compressing threads are carried. In cleansing the wound, *sponges* may be used, but they should then have been previously washed in carbolic acid solution to prevent infection of the wound; or clean *napkins* may be profitably substituted.

In the *removal of tumors*, as for example of the mammary gland, bleeding can often be prevented to a great degree by tearing the tissues with the end of the finger, rather than by cutting them with the knife. When enucleation is thus effected, the vessels contract, there is but little bleeding, the outlying diseased portions come away with the affected mass, and the operation is quickly over. Under certain circumstances, where the tissues are tight, and bind, and the divulsion cannot be conveniently effected by the end of the finger, knives with silver or rounded blunt steel edges—"dry dissectors"—may be resorted to. When after-oozing takes place, from incised wounds, or from the face of stumps, it may be checked by the use of cold water or ice, or better still by sponges or napkins wrung out of very hot water, or by hot water itself. In the application of the actual cautery, care must be taken to avoid the ignition of ether vapor, when it is the anæsthetic employed. Deep cauterization may at times be conveniently effected by Paquelin's thermo-cautery, but this should be tested before operation, since it often fails to become heated at the critical moment. The proper fluid to be used in this instrument is painter's benzine of 0.715 specific gravity. Wounds of operation, particularly when of any extent, should not be closed until all bleeding has ceased, since the presence of blood interferes with immediate union. For drawing the lips of the wound together, *sutures* of silk, or fine silver, or soft iron wire, may be employed. The latter should not be used upon the face or exposed parts, since the oxidation of the iron leaves a small discolored point which does not disappear for some time. When possible, the sutures should be inserted before the patient recovers from the influence of the anæsthetic.

Perhaps the most important matter in the healing of wounds is the establishment of free *drainage*. Surgeons may be greatly divided as to the particular form of after-dressing, but nearly all agree as to the necessity of drainage. It is therefore incumbent upon the operator to see that his wound is not closed too tightly, but that a free escape is afforded for all fluids which may form. In deep wounds, this can be best accomplished by the insertion, before closure, of a small, perforated, rubber tube, through which these fluids can escape. After six or seven days, the tube can be gradually withdrawn by cutting off half an inch or an inch daily; when the drainage through its track will be found sufficient to keep the wound free. If the rubber tube be left too long *in situ*, it may possibly serve to keep up the purulent discharge.

The *after-dressing* of the wounds of operation has been a matter of much discussion, and the surgical world, sometimes influenced by fashion, epidemic opinion, or honest conviction, has been greatly divided. Poultices, water dressings, dry dressings, earth dressings, cerate cloths, open air dressings, and many other forms of topical application, have all had in their day active supporters, and have doubtless furnished excellent results. At the present moment, the antiseptic treatment of Professor Lister is on trial. It has a host of ardent partisans, many lukewarm supporters, and some, perhaps not a great many, opponents. Whether it has realized, whether it will realize, all that has been claimed, and all that is hoped from it, remains to be seen. But the

earnest and enthusiastic efforts of Professor Lister have already wrought great good to surgery, in many ways; not the least being in the care and cleanliness in the treatment of wounds, which he has taught, and in the personal observation and attention he has enforced by his own example. As the antiseptic treatment of wounds will form the subject of a separate article, it is not necessary to consider it further in this place.

Yet apart from the antiseptic method in all its details, it is probable that, in a modified form, it can be made largely and conveniently available in the treatment of wounds of operation, and open injuries. A piece of lint saturated with carbolized oil, or carbolated solution, will answer every practical purpose, and may be substituted for the rather cumbersome special dressing of Lister.

No matter what dressing may be resorted to, the surgeon must still remember that it should at all times be inspected with repeated and scrupulous care; that soiled cloths, breeders of infection, must be at once removed; and that absolute cleanliness of the wound and all its surroundings must be rigidly enforced. If there be much suppuration, the carbolic acid spray from an ordinary atomizer can be advantageously employed. All dressings should be light, and in changing them great gentleness should be used to avoid disturbing the soft parts, and arresting or interfering with the process of union. If adhesive straps have been laid across the line of the wound, and it becomes necessary to change them, this should be done in accordance with the great indication, the preservation of local rest.

Treatment of Patients after Operation.

The after-treatment of operations may conveniently be considered as *local*, and *general*. As regards the former, the part must be placed in the position of greatest comfort to the patient, and properly supported, while all strain upon the tissues is avoided. The position, too, should be selected so as to favor drainage, and the dressings should be as light, and as little cumbersome, as possible, while every attempt should be made to favor early union. If the sutures used are metallic, and are productive of little irritation, they may be left until it becomes evident that they are of no further service, or until they begin to cut out, when they may be removed. If the arteries have been tied with thread or silk ligatures, the latter must be left until it is apparent that they are separating or falling. They must always be handled with extreme caution, and no force should be employed to effect their dislodgment, for fear of pulling them off prematurely, and thus giving rise to bleeding which might prove troublesome. In arranging the threads, before closing the wound, it is well, as a rule, to carry them out either at the nearest point, or at the angles, and they should be laid straight in the wound; care must also be taken to prevent them from falling into loops, or from becoming entangled one with another; otherwise, in removing one which has fallen, an unsuspected ligature may be unduly pulled upon. It is well, too, to count the ligatures, and to be quite sure as the case progresses that the full quota of threads has been taken away. Instances are not uncommon, where many ligatures have been applied, in which one or more have in some way or other become buried or hidden in the depths of the wound, and, to the mortification of the surgeon, have made their appearance by ulceration weeks after the wound had been regarded as firmly closed and cicatrized. When the carbolized gut ligatures have been used, their removal will necessarily be spontaneous and by absorption, and the surgeon need not trouble himself as to their coming away. Rest, support, drainage, cleanliness, the avoidance of unnecessary handling, with proper

attention to the ligatures and sutures, constitute in short the local after-treatment of the wound of operation. To these must be added constant watchfulness to detect the development of abscesses, and the requisite incisions for their evacuation should any form. In fulfilling the above requirements, the surgeon must bear in mind that, while it is incumbent upon him to do what is necessary, and that promptly, on the proper indications, he must nevertheless abstain from officiousness or fussiness.

After an operation has been finished, and the wound satisfactorily dressed, the patient should be placed in bed, well covered, and carefully watched until he has recovered from the effects of the anæsthesia. Until he has done so, he must not be left alone, or in the hands of an inexperienced assistant, or in those of a nurse. It is the duty of the surgeon himself not to leave his patient until he has recovered at least sufficient consciousness to answer questions. The *general* after-treatment now begins, and upon it the ultimate issue of the case in no little degree depends. The first general indication is *rest:* rest to body and mind, relief from excitement, and freedom from pain. There is no doubt that these ends can be best brought about by the exhibition of an *anodyne*, and in no better way than by the subcutaneous use of morphia. A hypodermic injection of from a quarter to a half grain, will usually be sufficient to prevent pain and soothe restlessness. In exceptional cases more may be required, but the amount mentioned is usually sufficient, and, if not, it can be repeated. When it acts, the patient passes off into quiet sleep, and thus escapes the shock of pain which would otherwise greet him so unpleasantly on his recovery from anæsthesia. Of course, if an hypodermic have been given prior to the operation, this fact must be remembered in apportioning the after-medication. Not unfrequently after operation a good deal of *nausea* is present from the effects of the ether or chloroform. This commonly passes off gradually in a few hours, but sometimes continues throughout the night and even into the next day. When prolonged, it is difficult of treatment and not readily amenable to drugs. Occasionally it is relieved by ice in small quantities, by a teaspoonful or so of brandy, by carbonated waters, or by sinapisms to the epigastrium. It is sometimes ameliorated by vomiting, although not always.

In most cases of serious operation, especially if the nausea above described be present, the patient does not desire food of any kind, and, indeed, cannot retain it even if he forces it down. Great care must, therefore, be exerted in selecting the proper nourishment. It would seem that the diet most suitable under these circumstances was *milk*, or milk diluted with lime-water. This can generally be retained, is palatable to the patient, and gratefully assuages the thirst which is often so terrible to bear. Physiologically considered, too, it is that form of nutriment best adapted to cases where there has been much loss of blood; in fact, it would almost appear to satisfy a natural craving. Few patients object to it; and even those who at first say that they "cannot bear milk—it does not agree with them," yet take it willingly and even eagerly after the first trial. In administering milk, caution should be exercised as to the quantity. Too much should not be given at one time, but small quantities, repeated, and taken slowly. If the stomach be very irritable, an ounce and a half or two ounces every two hours will be sufficient. If the patient be very weak, brandy or whiskey can be given with the milk, or in alternate doses, according to the indications. *Beef essence* is not always well received by the stomach, nor are soups, however nicely they may be made. They are undoubtedly satisfactory articles of diet after the lapse of a day or two, but are not so well borne immediately after the operation. In many cases, particularly where thirst is annoying, *acidulated drinks* may be admin-

istered with benefit. The combination of milk with occasional small quantities of lemonade may at first thoughts appear to be somewhat incongruous, yet clinical experience fully asserts their value, especially in operations upon the urinary organs. As the case progresses, and as the patient improves, the diet may be increased in strength and quantity, and richer soups, the breast of a chicken, or the more digestible meats may be given. In every instance, the selection of diet must be governed by the circumstances of the patient. If there is a tendency to inflammation, it must be light; while for those who are weak, or who have suffered much from shock or hemorrhage, fuller diet is demanded. A good deal can be left to the patient's inclination, for he can sometimes judge better than those who are around him as to what he can most easily retain on his stomach; and his fancies in this respect should be considered when not obviously objectionable.

Before operation, the patient should be instructed to empty the *bladder*. If this be not attended to, an early use of the catheter may be demanded, since many persons experience great difficulty in voiding their urine after operation. It is, perhaps, unnecessary to state that the *bowels* should be freely evacuated on the morning before the operation. This is all the more to be insisted upon, since constipation usually follows operation. This may be due in part to the loss of blood, and in part to the opiates given, and the confinement to bed. It is not, however, a circumstance which need give rise to any uneasiness, or indicate hasty administration of purgatives. It is usually corrected by the change of diet, and, if it is not, a little castor oil after a few days will answer every purpose. The use of purgatives in any shape too soon after operation is greatly to be deprecated. In the first place, they are unnecessary, and, in the second, too early a movement of the bowels sometimes overtaxes the patient's strength and is followed by exhaustion. Should the bowels act, it is well to give a little stimulus at the time.

In rare instances, patients are met with who bear operations with wonderful composure and recover with remarkable facility.

The writer can recall, as such, a case of secondary amputation at the knee-joint, upon a delicate lady. On the following morning she was found sitting up in bed knitting, and she had insisted upon her customary diet without any abatement. The popliteal ligature separated on the tenth day, the wound healed by first intention, and in reality in less than ten days she was well.

Another singular instance occurred in an Irish soldier whose humerus was shattered in action by a ball, and whose arm was removed close to the shoulder-joint immediately afterwards. He walked on the same day, under a broiling sun, fifteen miles, carrying his gun, knapsack, and full accoutrements, and in the evening was found acting as a volunteer sentry on guard. He was with difficulty placed in hospital; the ligature separated early, and his recovery was as rapid and wonderful as in the case above given. In neither of these instances was traumatic fever developed.

There is yet one other matter which it is well for the surgeon to see to, and that is the character of the patient's surroundings. Not only should his room be well ventilated, but it should be light and cheerful; and, as he convalesces, he should be provided with proper books, and resources to relieve the tedium of confinement, and to occupy his mind. At a later period, and where no positive reason to the contrary exists, if he be a smoker, he may be permitted his cigar or pipe. Growing flowers and plants in the chamber have been objected to on the ground of their tendency to absorb oxygen and give off carbonic acid. But practically this is an error, for in fact the plant lives on carbonic acid, and during daylight, while its nutrition is going on, carbonic acid in large quantities is absorbed and oxygen given off. At night the

nutrition of the plant is suspended, and the reverse process takes place in the exercise of its function of respiration, oxygen being absorbed and carbonic acid being given off, but in quantities so small as scarcely to demand consideration. There is, therefore, from a chemical point of view, no question as to the propriety of having living plants and flowers in moderation in a sick room, if proper ventilation of the latter be looked to. Æsthetically considered, nothing can be more delightful and cheering to a convalescent than their presence, since they are always lovely in themselves, and doubly so in their happy influence on a sick man's mind.

Traumatic or Surgical Fever.

After most operations, especially if they be of any magnitude, the patient suffers from more or less febrile disturbance. This is known as surgical or traumatic fever, and generally makes its appearance a few hours after the operation, or during the ensuing night, or on the following day. It varies greatly in intensity; at times it is very slight, and at times sharply characterized from its inception. The patient is at first restless and uneasy, tosses about, and complains of heat and thirst, with more or less headache; the face flushes at times greatly, the pulse is quick and tense, the skin feels hot and dry, there is no appetite, but much thirst, and the tongue becomes dry and furred. If the fever runs very high, there may be some mental disturbance; the patient is a little flighty, and in extreme cases even delirious. The temperature of the body is increased, and rises to 102° or 103° Fahr., sometimes to 104°. The secretions are disturbed, the urine is scanty and high colored, and there is commonly a general exacerbation of all these symptoms in the latter part of the day, or during the evening. In ordinary cases all these symptoms lessen about the third or fourth day, and gradually pass away; their subsidence being marked by the increasing comfort of the patient in every respect. Traumatic fever rarely lasts more than a week, and usually only three or four days; it often assumes a somewhat remitting character. All persons are not equally liable to the occurrence of this fever, nor is its violence always in proportion to the gravity of the operation or injury. As already stated, it may be altogether absent; in an aggravated form it may follow the slightest operation. Malarial surroundings, exposure, intemperance, mental disturbance, and debilitating influences generally, probably act as predisposing causes to its development.

The subject of traumatic fever has been carefully investigated by Billroth, who, as the result of his observations, declares that this fever, like any other inflammatory fever, depends upon a poisoned state of the blood, induced by the absorption or passing of various materials from the seat of inflammation, or the surface of the wound. At the same time, it must be observed that the fever in question sometimes makes its appearance very early after operation; before, indeed, sufficient time has elapsed to permit decomposition to have taken place, which forms so essential a part in the theory of blood-poisoning. It would, therefore, seem likely that the shock of operation, the manipulation of the tissues, the nerve lesions, the swelling and resulting tenderness, have just as much to do with the development of surgical fever as the more obscure causes which have been adduced. Left to itself, this fever in the vast majority of cases soon diminishes, and, by the time suppuration has been fairly established, ceases altogether. Should it reappear, it carries with it the suggestion of fresh local mischief, such as the formation of abscesses, or the extension of the inflammatory process to other parts, neighboring or removed—possibilities which demand careful investiga-

tion from the surgeon. The occurrence of rigors, in traumatic fever, is not common; and in this respect it differs, as in many others, from the urethral fever so often encountered after operations on the urethra and bladder.

The *treatment* of surgical fever hinges on the patient's special condition, and must be met by a judicious application of well-known general principles. If he be very weak, he must be supported; if he be plethoric, and the fever run high, with great increase of temperature, sedative fever mixtures adapted to restore the secretions, with the addition of a little aconite, can be advantageously exhibited.

Conditions Determining the Results of Operations.

In estimating the risks of operations, and in comparing the hazards of those of the past with those of the present day, it is proper to consider the advances which have been brought about by modern surgery. An operation has always been regarded by the community as little short of a catastrophe, even under the most favorable circumstances, and certainly the operation of former times was appalling in its nature when contrasted with the same operation as now practised. For the surgical mind, it is scarcely possible to contemplate anything more terrible than the amputation of a limb before the discovery of anæsthesia. All of the attendant circumstances were calculated to strike terror to the mind of the trembling patient; the mental anguish before being placed upon the table; the horrid pain of the operation itself; the loss of blood, and shock, combined, were sufficient to intimidate the bravest, and must necessarily have influenced in no slight degree the issue of the case. But all these horrors have almost vanished since the advent of anæsthesia, hypodermic medication, and the application of Esmarch's elastic bandage. The patient now possesses at least the assurance that whatever may be the surgeon's duty, he himself will feel no pain; that his condition while under the knife will be one of unconsciousness, and that when he returns to himself, it will be with but the memory of a dream. It is somewhat difficult to compare accurately the statistics of past operations with those of the present day. By some, the risks of operations have been regarded as increased rather than decreased by the discovery of anæsthesia. But it would seem to be scarcely possible that such in reality could be the case. It is certain, however, that the number of operations has greatly increased; the surgeon of to-day dares to do far more than his predecessor would have been willing to attempt, or indeed justified in attempting. The elimination, too, of the factor of pain during operation, renders patients more willing to submit to operation than formerly; while, again, it would seem as if the causes demanding operation had increased greatly, not only in number but in gravity. The more extended use of machinery, the high velocities at which it is driven, the increased chances of accident attendant upon great engineering projects, the altered means of transportation, the more general use of railway and street cars, have all combined to produce a large class of the "seriously injured" formerly unknown. The shock of accidents resulting from all such violent causes must consequently be necessarily augmented. Granting, however, although not proven, that the risks attendant upon operation are now increased, it is but fair to assume that these augmented dangers, if any, may be fairly charged, in part at least, to the changed pursuits and habits of men, rather than to the discovery of the blessing of anæsthesia.

Much has been said and written of late years concerning "hospitalism," or the gathering of large numbers of patients into one building. Undoubtedly the effects of overcrowding are in the highest degree deleterious, but it must

be remembered that, during the last quarter of a century, hospital facilities and accommodations, the world over, have been infinitely improved and extended to meet the demands of the growing influx of patients. Far more attention has been paid to the wants and necessities of the latter, and more thought and enlightened study have been paid to ventilation, drainage, and cleanliness. The necessity of increased air space has been recognized, the pavilion system of wards has been adopted, and the diet scale has been changed for the better, and in accordance with physiological teachings. It would thus seem that, while the demands upon the hospital are now greater and more imperative than they once were, at the same time every effort has been made to satisfy these claims, and that the present hygienic surroundings of the hospital patient are more favorable than they have ever been before.

Before an operation is undertaken, the surgeon should always critically examine his patient, so that he may form a correct estimate of his general aptitude to undergo operation, and of the ability of his constitution to sustain the fresh weight about to be imposed upon it. This examination must be conducted systematically, and must embrace the general condition of the patient's system, his habits, and an inquiry into the state of his special organs, as to whether the latter are, or have been recently, diseased. It is not always easy to decide if a man is or is not a good subject for operation. There are so many factors which enter into the determination of this question, that the surgeon is liable to deceive himself, or to be deceived, unless his study of the case before him is critical and thorough.[1]

General Condition of the Patient.—First, as to the general constitution of the patient: what is it which makes, to use the terms of the insurance companies, a "good risk"? Undoubtedly they are the best subjects for operation, in whom nutrition is most thoroughly effected, in whom assimilation is well performed, whose secretions and excretory functions are in perfect working order, and in whom consequently there is no organic disease. Now these conditions may be found both in fat and in lean subjects.

Obesity is usually regarded as one of the contra-indications to operation, but it must be remembered that many persons who are in perfect health are fat, and that any undue falling off from this state is attended with more or less loss of health. On the other hand, there are those who are normally lean. Fat is not in itself an evidence of deranged health, if it be natural or hereditary; but excessive fat, or sudden or precocious development in this direction, must be regarded as one of the evidences of something being amiss constitutionally; especially is this the case if fatness be unaccompanied by a healthy condition of the skin and capillary system, or if the development have occurred suddenly, or from habits of drinking, gluttony, or indolence, and when the patient is inert, and unwilling or incapable of taking proper exercise, or exertion. Under such circumstances, the person is apt to be flabby or loose in his tissues; and there is a want of that firmness and contractility of the skin and subjacent structures which is inseparable from health. This state is not unfrequently observed in women approaching or passing middle age, and, when found, unquestionably indicates that the possessor is no longer in the best condition of health, nor well suited to undergo the risks of a surgical operation. In such persons, the wounds of operation do not heal well; there is

[1] For an elaborate and exhaustive study of the risks of operations, and of the causes influencing their results, the reader is invited to consult the published lectures of Sir James Paget, who has fully treated of these subjects in paragraphs which have already become classical. So great has been his experience, so close his observation, and so lucid the utterance of his beliefs, that it seems as if little else were left for other pens; and the writer of the present article has accordingly not hesitated to make free use of the teachings of this eminent surgeon.

commonly much suppuration and burrowing of matter, and a tendency to sloughing. These conditions all predispose to exhaustion, and to intercurrent diseases of a low type.

The state of *plethora* which is marked in those who are usually spoken of as "full blooded," is also one which requires careful consideration from the surgeon. If this condition is confined simply to the external surface, and is not accompanied by internal congestions, or derangement of the viscera, and has not been produced by free living, there is no reason why the surgeon should refrain from operating. He must simply be on his guard against the development of intercurrent affections of an inflammatory type, to which such persons may possibly be naturally disposed.

Leanness is not a bar to operation, unless it result from non-nutrition, defective assimilation, or excessive excretion, in which case it will probably be found to depend upon some perverted function or organic disturbance. When loss of flesh has occurred from overwork, or too great mental or bodily strain, the surgeon should be careful, and, except in urgent cases, should defer operation, if possible, until the patient has by proper therapeutic and dietetic measures been brought to a better grade of health. In short, it may be repeated, as already stated, that when the deflections from the standard of health have been produced by impaired nutrition, or organic disease, the patient is not, and will not be, in a suitable state for operation until the exciting cause has been remedied or removed to the greatest degree possible.

Habits of Patient.—Habits, bad habits, play an important part in rendering a patient unfit for operation. The evil effects of the excessive use of stimulus; opium eating; the taking of chloral or other pernicious agents of this kind, are so well known as scarcely to demand more than a passing mention. *Drunkenness*, too, in its varied forms, is one of the most familiar examples of the contra-indications to operation. But here there is a difference of degree. The quiet drinker, who "soaks" over night, and, while rarely quite drunk, seldom goes to bed really sober, is, perhaps, one of the worst subjects for an operation. In his case there is in all probability more or less organic hepatic trouble, or, if this condition is not yet fully established, there is a tendency in that direction. In him the powers of life are lowered, and there is a lack of that vital resistance necessary to carry him through the perils of an operation. In such cases, too, there is always more or less tendency to the development of delirium tremens, and, when this occurs, the prognosis always becomes grave. In confirmed, steady drinkers, the outlook after surgical interference is bad, and more so after accidents which demand amputation. Even here, however, poor as the chances are, the probability is that primary amputations are less dangerous than secondary—the latter when of the severer kind not unfrequently ending fatally.

There is another class of intemperates upon whom the effects of operation are not so disastrous as in the group already referred to. These persons indulge occasionally in fits or bouts of drinking, the duration of the debauch usually lasting from two to six days. These periods of carouse are succeeded by weeks or months of sobriety, during which time the individual attends to his business actively and industriously. Operations performed during these intervals of abstinence, are not necessarily attended by any very great amount of increased risk to life; nevertheless the surgeon must watch carefully against the advent of untoward symptoms. It must also be remarked that, in these unfortunates, the craving for drink is apt to be developed at times until it assumes almost the form of mania. To the practised eye the approach of these drinking periods is unmistakable, the patient's manner being marked at times by fits of irresolution, and at times by a general state

of exaggeration and excitement of the mental functions—the sure forerunners of coming trouble. During and preceding these attacks no operation should be attempted, unless in the utmost emergency.

In close relation to excess in drinking, stands overfeeding, or *gluttony*. Overindulgence in the pleasures of the table undoubtedly adds to the risk of operation, inasmuch as an abnormal condition is thereby developed, accompanied by bodily indolence, and by perversion of the natural excretions. This is the case when large amounts of meat are consumed, and when deficient exercise interferes with the proper elimination.

Influence of Nervous System.—There is another class of persons upon whom the surgeon at times almost fears to operate, in consequence of the existence of what is ordinarily described as a "nervous" state of mind and body. It is possible, however, that fears in this respect are often exaggerated. A patient may be timid and nervous in the highest degree, with a mind worked up to a point of greatest tension; his dread of operation may be so intense as to give rise to fears of subsequent shock; and yet, after all, the operative dangers in such a case may be imaginary rather than real. As long as organic disease does not exist, the surgeon may hope and indeed count upon this depression, dependent upon mental causes, passing away as soon as the contemplated operation has been performed. Here the reaction is not, usually, as quick and marked as was the pre-existent mental prostration, and, the depressing cause once removed, the patient will probably pass to a corresponding condition of contentment of mind in every way favorable to the production of a happy result.

Operations are often demanded upon feeble persons in whom, although there are no evidences of positive disease, there is an absence of robust or even of moderate health. Such individuals are apt to have been overworked or worried. They have been taxed either mentally or bodily beyond their powers of endurance, and are in no condition to sustain the weakening and depressing effects of operation. In such cases, all surgical interference should, if possible, be delayed until, by rest and judicious medical treatment, the general condition has been sufficiently improved.

As a familiar example of the class of patients first referred to—the mentally overtaxed—may be cited the hard-worked man of business, whose mind has long been kept on the strain by the exacting nature of his calling, and whose face betokens the anxiety and harassment of his vocation. His aim is the accumulation of money, and for its accomplishment all other objects must give way—even health itself. Of the latter class—those worked beyond bodily endurance and ill fed—there are in this country fortunately but few, the rate of wages being usually sufficient to provide good food and a home for the poorest laborer, if he be industrious.

Age and Sex.—*Age* exercises a decided influence upon the results of operations. As a rule children bear operations well, and, while they are peculiarly susceptible to pain and shock, they are not liable to the mental depression which acts so powerfully in after life. They are usually healthy, and their internal organs are not so frequently the seat of organic diseases, the result of long-continued or abused action, as those of adults. Their growing condition, moreover, favors the process of repair, and the union of wounds. The chief danger to them is shock, consequent upon pain and hemorrhage; the latter undoubtedly acts powerfully in this direction, but, this once overcome, the wounds of children heal kindly and rapidly, and they are rarely subject to the secondary complications of pyæmia or septicæmia; tetanus may at times occur, but more often as the consequence of lacerated or ragged

wounds, than of simple operations. Another important feature in the favor of children, as subjects of operation, is the readiness and comparative comfort with which they bear confinement. Easily satisfied and amused, they soon accustom themselves to their new condition, and pass through a long period of confinement to bed, possibly subject in the mean while to exhausting discharges, in a manner unknown to those of more mature age.

The tendency of children to suffer from the exanthemata must always be remembered, and no operation should be attempted on them when exposed to these affections. There is also in children, as has been pointed out by Sir James Paget, a special liability to the occurrence of scarlatina after operation. Why this should be so, is not clear, but it seems probable that the shock of operation upon children carries with it a predisposition to the development of this disease, especially if it is epidemic at the time. The same writer also states that the type of the disease, occurring under these circumstances, is somewhat modified, and the period of incubation shortened. In some children the disease appears on the whole surface at once; in others, more decidedly upon the limbs; sore throat and desquamation are observed in some, and not in others. The development of this affection necessarily adds to the hazard of operations in childhood.

The performance of certain operations upon children is at times difficult, and demands a high degree of anatomical knowledge, in consequence of the contracted space in which procedures, often of a delicate and complicated nature, must be practised. Yet, as a rule, the average child may be regarded as a good subject for operation, and in this respect contrasts strongly with persons of advanced age. In the latter, the powers of life are already weakened, and it requires but little to disturb the vital equilibrium. The chances of the existence of organic disease in one or more of the great viscera, and, in men particularly, in the genito-urinary organs, must be considered. No surgeon would deliberately select a very old man as the subject for operation, and yet in many instances such patients will recover from operations wonderfully well. Still, this cannot be anticipated, and must be looked upon as an exceptional circumstance. Age cannot always be measured by years alone; a good deal depends upon the constitution, and upon pre-existent habits, and they have the best chances of recovery who are in the best general condition of health. When operations are called for upon the aged, every effort should be made to prevent hemorrhage and shock, and such patients should not be kept in bed longer than is absolutely necessary. All depleting measures should be carefully avoided, and the diet should be of the most nourishing, and, if necessary, stimulating kind.

Sex.—As far as sex is concerned, there does not seem to be a great deal of difference as to the capacity of men and women to sustain operations. The latter are undoubtedly more patient, more accustomed to endure suffering, and more tolerant of confinement to house and bed. At the same time, there are certain physiological conditions of womanhood which must be borne in mind in the selection of the time of operation. Thus the *menstrual period* should be avoided. The woman is then in a state of nervous irritability, and often of positive pain. Her mental and physical functions are in a degree perverted, and her judgment and self-control disturbed. In fact, she is not then in a state to be exposed to any increased or unnecessary irritation. The best period for operation in women is probably from five to eight days after the cessation of the menstrual flow. After operation, it frequently happens that the menses will make their appearance too soon, and in anticipation of the proper period; and the nearer to the latter that the operation is performed, the more apt is this anticipation to occur.

Operations during *pregnancy* should be avoided when it is possible. Sometimes this cannot be done, the conditions demanding surgical interference being imperative. When such is the case, every precaution should be taken to guard against excessive nervous disturbance, and the risks of miscarriage. It must here be observed that when wounds and accidents do occur during gestation, the healing and reparative processes are usually very rapid. During *lactation*, operations should also be avoided, as prejudicial alike to mother and child; nor should surgical interference with the mammary gland be needlessly undertaken. Tumors in this region should never be removed at that time, as much on account of the probable hemorrhage, as for other reasons.

Race and Temperament.—The influence of *race* is potent in determining the results of operations. Strange as it may seem, the black races and the Oriental nations sustain injuries and operations best; next stand the Anglo-Saxons; and, according to M. Chauffard, the Latin race is as far behind them as they are behind the black race. The immunity of the Chinese and Japanese to mortality after operations is remarkably shown by the various reports of medical officers serving in the East. It is stated that pyæmia is a rare occurrence among the *Chinese*, and in a recent report of 138 operations for lithotomy performed on persons of all ages and occupations, from two years old to eighty, but eight deaths occurred.[1] A similar immunity is said to be enjoyed by the *Japanese* in regard to pyæmia, septicæmia, tetanus, and erysipelas. It is difficult to understand why this should be, unless the explanation is to be found in the fact that the lower classes of these races live chiefly on vegetable diet and fish, and eat but little meat.

In our own country, the *negro* has generally borne injuries and operations well, provided that he has not been exposed to the after vicissitudes of cold and dampness. This was remarkably shown in the experience of the negro brigades during the late American war. According to the observation of the writer, when these soldiers, injured in battle, were cooped up in overcrowded and overheated hospitals, they did well; when, however, removed to well-ventilated pavilion hospitals, and placed under such hygienic conditions as are most favorable to the white American soldier, they did badly, suffering severely from intercurrent pulmonic and other acute inflammations. In the daily practice of our hospitals, the negro is, we think, regarded as a satisfactory patient, and one of whose case a favorable prognosis can usually be formed. Whether this be due to the happy mental condition of his race, and to its characteristic freedom from care, cannot perhaps be clearly shown.

The *Irish*, from their peculiar mental elasticity, also bear operations well, and so do the more phlegmatic *Germans*. The *American* is not so good a patient; his activity of mind renders him restless and impatient of restraint; he looks anxiously forward to the end of his convalescence, and not infrequently ventures out of doors too soon, and thus hinders his own recovery.

The influence of personal *temperament* is not less than that of race. A happy and contented disposition contributes greatly to convalescence after operation, for it enables the patient to obtain and enjoy that rest of body as well as of mind which has so much to do in bringing about recovery.

Influence of the Seasons and Weather on Operations.—The popular as well as the professional mind has long since recognized the influence of the weather on certain general and local conditions of the body. Its effects upon

[1] Imperial Maritime Customs. Medical Reports, 1878–9.

rheumatism, neuralgia, diseased bones, and the ends of stumps, are examples in point. But, strange to say, its precise relations to surgical operations, and the influence it exerts upon their results, had never, as far as we know, received that precise study which they deserved, until the year 1869, when Dr. Addinell Hewson, of Philadelphia, published in the Pennsylvania Hospital Reports for that year, a paper on the "Influence of Weather on the Results of Surgical Operations." This was followed, in 1870, by the published lectures of Dr. Richardson, of London, in the Medical Times and Gazette for January and February of that year. The observations of these two investigators agree in the main, and may be thus epitomized. It must here be stated that by "the weather" is meant the measure of the changes of the conditions of the temperature, humidity, and pressure of our atmosphere, relatively to each other. Dr. Hewson's deductions are based upon the observation of 259 operations performed at the Pennsylvania Hospital in the thirty years preceding 1860, during which period a meteorological register had been faithfully kept by Dr. Conrad, the apothecary. Taking, as the expression of the changing weather, the barometrical condition, and regarding it as ascending, stationary, and descending, Dr. Hewson found that, of the 259 operations, 102 were performed when the barometer was ascending, 91 patients recovering and 11 dying, giving a death-rate of 10.7 per cent.; 34 operations were performed when the barometer was stationary, giving 26 recoveries and 8 deaths, a mortality of 20.6 per cent.; and 123 operations were practised when the barometer was descending, with 88 recoveries and 35 deaths, a mortality of 28.4 per cent. In other words, with an ascending barometer the mortality of operations was a little less than eleven per cent., with a stationary barometer more than twenty per cent, and with a descending barometer more than twenty-eight per cent. In the same general way, it was observed that the results of operations were most favorable in autumn and winter, and least so in summer. The most happy month for operating was October, then January, then April. The frequency and mortality of pyæmia bore a direct relation to low barometrical pressure and moisture of air, while the deaths from shock occurred in a constant ratio with the opposite condition, dryness of weather.

The deductions of Dr. Richardson tend strongly in the same direction, for he finds that the most favorable time for operating is when the barometer is steadily rising or steadily high; when the wet bulb thermometer shows a reading of five degrees lower than the dry bulb; and when, with a high barometer, and a difference of five degrees in the two thermometers, there is a mean temperature at or above 55° Fahr. On the other hand, the time is unfavorable for operations when the barometer is steadily falling, or steadily low; when the wet bulb thermometer approaches the dry bulb within two or three degrees; and when, with a low barometrical pressure, and approach to unity of reading of the two thermometers, there is a mean temperature above 45°, and under 55° Fahr.

Such are the results of precise observation, and they seem to accord with the general empirical idea that large operations should not be unnecessarily performed in very warm weather—at all events in the height of an American summer, when the thermometer frequently ranges from 90° to 100° in the shade. We all know that at such times a certain degree of lassitude is felt by every one; and it would seem reasonable that the combined influence of intolerably warm days and breezeless sultry nights, must be to weaken the constitution temporarily, and to deprive it for the time being of those powers of resistance which are so essential to speedy convalescence after operation. It is not likely, as is commonly supposed, that wounds heal less kindly in warm weather, but it is certain that debilitation from any cause does seriously interfere with the general recuperative powers, and the main consideration after

operation is the patient's strength. From what has been said, it will be seen that the *season* has not as much to do with operation as the *weather*, and in this relation the tendency to intercurrent diseases must be borne in mind. During the winter, these are most apt to involve the pulmonary organs, in the forms of acute bronchitis and pneumonia, while in the summer, the abdominal viscera suffer from the acute internal inflammations, accompanied by diarrhœa.

Locality has something to do with the result of operations. When the patient is exposed to damp and depressing exhalations, and to malarious influences, wounds do badly, and convalescence, particularly after the large operations, is tardy. The reverse is the case when the atmosphere is dry and exhilarating, as on the mountain slopes. The sea breezes also act as a most powerful tonic. It would be easy, from the recent military experiences of our country, to adduce example after example in support of these assertions. It has often happened that, after great battles, soldiers who had undergone amputations and other severe operations, have from military exigencies been left for a time in field hospitals, planted in unhealthy districts, and swept by marsh exhalations. Under such circumstances, wounds and stumps not unfrequently did badly, and assumed a sloughing and unhealthy appearance. As soon, however, as the men could be removed to hospitals in salubrious localities, an immediate change in their condition was observed. The wounds cast off their unhealthy character, and entered upon active reparation. No operation should be performed, except in cases of emergency, in any locality in which an epidemic is prevailing, such as diphtheria, erysipelas, cholera, yellow fever, and possibly influenza of a bad type.

Influence of Visceral Affections.—There are certain organic diseases of the great viscera which exert a direct and unfavorable bearing upon the chances of operation. Chief among these are affections of the heart, lungs, and kidney.

Heart and Arteries.—In regard to the heart, it is probable that the risks of operation are not always so seriously increased by disease of this organ as is generally supposed. A great deal will depend upon the degree of cardiac trouble, the evil consequences which have attended it, or are present at the time, and its duration. It not unfrequently happens that cardiac disturbance dependent upon valvular changes is relieved by the hemorrhage which attends an operation. If the amount of disease observable is such as to greatly disturb the patient, and to interfere with his circulation and respiration, the risks of shock, either at the time of operation or subsequently, must undoubtedly be recognized. Fatty degeneration of the substance of the heart is attended by great danger, greater probably than the more simple degrees of valvular obstruction. These constitute the class of feeble hearts, which are strongly influenced by shock and blood loss; and to patients thus affected, ether should be given in preference to chloroform on account of its stimulating effects.

Sir James Paget, in his lectures on the risks of operations, has drawn attention to the manner of the heart's action when it is believed to be healthy, and to the phenomena of the pulse. He tells us that a slow pulse does not forbid operation, nor does an accelerated one necessarily do so, provided it be not accompanied by organic disease. Children and young persons of nervous temperament have often very rapid pulses, and the surgeon, in deciding upon the propriety of operation upon them, should be guided, not by the pulse alone, but rather by noting whether the respirations are proportionately rapid. In

some persons, a pulse may beat 120 or 140 in a minute, and yet indicate no trouble if the respiration do not exceed 20 or 25. The same condition may be observed in some old persons, who may still be good subjects for operation. This plan of checking the pulse by the respiration is also to be followed in cases of individuals recovering from sharp hemorrhages, when the pulse is often quickened, while the respiration is proportionately slower. Habitual irregularity of the pulse, not accompanied by valvular changes or degeneration of the heart tissue, need not be seriously feared in estimating the chances of operation.

In giving due weight, however, to the effect of organic cardiac disease, it must be remembered that, in addition to its immediate influence, it is often indicative of grave changes in other portions of the system, and notably in the arteries. Thus aneurism may be present, or degenerations in the arterial walls, which may forbid or modify the performance of an operation. Arterial degeneration, not in itself a matter of great importance in minor operations, or in those upon the face or trunk, becomes a serious affair in amputations, and in the ligations of large vessels. Not only does this condition favor secondary hemorrhage, but it also predisposes to defective reparation and extensive sloughing. Indeed, it is one of the causes which produce the high rate of mortality after amputation of the lower extremities in old persons.

Lungs.—The question of operating when there is coincident disease of the lungs, is one of the gravest questions which can be presented to the consideration of the surgeon, and, unfortunately, it is one of everyday occurrence. During acute inflammation of these organs, of course there can be no hesitation as to the proper course. No operation should be then performed unless for the most exceptional and urgent causes. Interference with the pulmonary circulation is too serious a matter to be lightly encountered after operation, and the inconveniences incident to a forced position, difficulty of breathing, and the rack of coughing and expectoration, must necessarily exert a harmful influence, locally as well as constitutionally, upon the issue of any surgical operation demanding quiet and rest. The matter, however, assumes a different aspect if tuberculosis is present; when the patient is suffering from phthisis, and at the same time from some other ailment or casualty necessitating surgical interference. If he has received an injury or compound fracture, demanding amputation, there can be no hesitation. His only salvation may lie in the amputation of the limb, and the condition of his lungs has, for the time, nothing to do with the decision as to the propriety of operation. It may affect his after chances, but the necessity of the case demands that he shall run this risk, and there is no alternative. The case is far different, however, when the operation to be decided upon is one of expediency, rather than of absolute pressing necessity, as, for example, the removal of a tumor or hemorrhoid, the amputation of a limb for a scrofulous bone or joint, or the division of a fistula. The operation in these instances is one which in ordinary states of the system is highly proper, and which ought to be done. Is it right to attempt it upon a phthisical patient?

The answer to this question is not in reality as difficult as it seems at first sight, and is based upon a careful balancing of the patient's chances of comfort and life. In the first place, the surgeon ought to make a thorough examination, physical and otherwise, of the condition of his patient, in order to determine whether the phthisis is, in Paget's words, "active, acute, and progressive," or "passive, chronic, and suspended." If it be the former, no operation of magnitude should be attempted, since the course of the disease would be probably hastened, and the patient's life shortened by the shock of operation, the subsequent febrile disturbance, and the possible establishment of a second

source of discharge and constitutional drain. If, on the other hand, the disease of the lung has been of long continuance, but is now quiet, and is not making active progress, there is really no reason why an operation, if necessary, should not be resorted to. Yet it must be quite clear to the surgeon, that the proposed operation will make less demand upon the strength of the patient, than the cause for which it is performed is already doing. Thus it would unquestionably be proper to remove a limb for a suppurating joint or diseased bone, whatever the cause of the lesion might be, if it were quite evident that the patient's vital powers were giving way under the exhausting drain. It not unfrequently happens that both local and constitutional evidences of scrofulosis or tuberculosis exist in the same person, the deposit in the lung being accompanied by a disorganized joint. The propriety of amputation here depends upon the precise pulmonary condition. If the phthisis be far advanced, and the lung already breaking down, operation is usually inadmissible; but if the lung be as yet but slightly affected, there is always the possibility that its condition may be improved by the removal of the source of local irritation.

It is well known that *fistula-in-ano* frequently occurs in phthisical patients. By most of the surgeons of a past generation, and indeed by many of the present day, the existence of anal fistula was and is regarded as rather favorable to the patient than otherwise, it being held that it acts as a derivative, diminishing the progressive development of pulmonary tuberculosis. Of late years, this opinion has been challenged, and there are not a few, including many of the most learned and practical pathologists of the present day, who believe that the reverse is the case; and the belief is gaining ground that the fistula acts as a supplementary weakening discharge, rather than as a revulsive. The propriety of operation in such cases follows as a matter of course, with the proviso that the attempt to cure fistulæ occurring in phthisical patients must be restricted absolutely to those in whom the disease is incipient, or at all events not progressive. Here, as in other instances of tuberculous and strumous affections, it would then seem proper to attempt the cure of the affection by operation, remembering, however, that in all such cases there is an indisposition to healthy granulation, and that the wished-for cure may not always be accomplished. Dr. Van Buren, in his excellent treatise on diseases of the rectum, expresses himself strongly on this matter. He says that while no judicious surgeon would operate for fistula upon a patient with advanced cardiac disease, or with cirrhosis of the liver, Bright's disease, or cancer, yet in pulmonary disease the tendency of opinion is becoming more favorable to well-considered operative interference. He adds:—

> "On the following points I do not hesitate to speak positively: there is no reliable evidence that the suppression of an habitual discharge can do any harm in these cases; on the contrary, it is pretty certainly a positive advantage to arrest it; and I would advise the attempt to cure a fistula in a patient with physical signs of phthisis, provided there were no positively advancing softening, or severe cough, because, in addition to stopping a waste, it would remove an impediment to exercise in the open air, possibly on horseback. The objections to operating where there is softening or hectic are, that the concussion from coughing, and the lack of power, might prevent the wound from healing, and that the use of the knife would necessitate confinement to bed, and thus injure the patient."

In all operations which the surgeon may attempt on phthisical or scrofulous patients, he must, as Paget has advised, carefully avoid keeping them too long in one atmosphere, lest he may bring about that gradual impairment of health which is so favorable to the progress of tubercular disease.

Urinary Organs.—The results of operations and of injuries are more powerfully influenced by organic disease of the *kidney* than by that of any

other organ. In health, the kidney would seem to exercise less influence upon life than the heart or liver; yet after traumatism, the recovery of the patient often depends upon the manner in which the kidneys are acting. The function of these organs is essentially one of elimination and blood purification, and upon their perfect working, the excretion from the blood of noxious elements to a large extent depends. An impaired kidney, which has undergone certain pathological changes, and which may be secreting urine containing albumen or sugar, or failing to excrete the usual amount of normal urinary products, may suffice for a while for the support of life, provided that no extra strain be put upon it. It is, however, an organ of a delicate and sympathizing nature, and is peculiarly susceptible to the shock of operation—indeed marvellously so, when the genito-urinary organs are concerned. The slightest disturbance often serves to modify and arrest its secretion, to such an extent as to give rise to fatal consequences. A careful examination of the urine should therefore invariably be made before any operation of magnitude is attempted, and, if necessary, this examination should be repeated at intervals. The steady presence of albumen, not dependent on febrile causes or mechanical impediment, especially if accompanied by renal casts, reveals the story of a kidney organically changed. Here all operation must be refrained from if possible, or, if imperatively demanded, the increased attendant dangers must be looked steadily in the face. The clinical import of albuminuria is familiar to every one, as indicating a tendency to the development of inflammations of the serous membranes, and of some of the viscera.

Two difficulties are met with in forming a diagnosis of renal affections. The first of these is the existence of disease in the bladder, attended by the formation of pus and albumen, and their collateral products. The second is the occurrence of chronic disease in the ureter, leading to its closure by thickening of its walls, or by the choking of its canal dependent upon the inspissation or hardening of inflammatory products. In each of these conditions the functions of the kidney are deranged, its secretion is interfered with, and a corresponding extra amount of work is imposed upon its fellow. When *cystitis* is present, it is absolutely impossible to form any idea of the manner in which the duties of the kidneys are being discharged. When ordinary *desquamative nephritis*—Bright's disease—is developed, it is always attended by œdema, dropsies, and other familiar symptoms. The *contracting kidney* is marked by intermittent albuminuria, and by the presence of renal casts. It is, however, an affection which progresses slowly, and its symptoms are at times obscure. Clinically speaking, the dangers of operations in this form of kidney are greater than in the ordinary form of Bright's disease. *Renal congestion*, accompanied by alteration or suppression of secretion, not unfrequently follows the simplest surgical procedures, such as catheterism, or the dilatation of a stricture. Its occurrence portends new and alarming danger for the patient, and it is therefore not improbable, as has been suggested by Mr. Reginald Harrison, that this is just the state so often productive of surgical calamities, the causes of which are puzzling, and apparently difficult of explanation.

Pyelitis, or suppurating kidney, often spoken of as the "surgical kidney," is frequently observed by the surgeon. In this disease the renal pelvis and calyces are inflamed and suppurating. The inflammatory action may extend into the secreting portion of the kidney, and, when pus is formed in quantity, we not unfrequently find after death that the ureter has been largely involved, sometimes presenting sacculi of considerable size, filled with purulent fluid. Viewing the very decided post-mortem appearances, it might be supposed that this condition could always be detected during life. Unfortunately its existence is often, perhaps most often, coincident with chronic vesical or prostatic disease, and the symptoms of its occurrence are therefore to some

degree masked, and at times difficult of recognition. It need scarcely be said that such a state of affairs bears terribly on the chances of operation. A kidney thus damaged, and forming pus, is unable to discharge its duties under ordinary circumstances; and certainly not when subjected to the shock and increased irritation produced by urethral and vesical operations.

Disease of the *bladder* also, like disease of the kidney, with which it is usually associated, exerts a most unhappy effect upon the issue of operations, especially when it is chronic, or occurs in old persons.

The occurrence of *sugar* in the urine is not a whit less serious than albuminuria, and, if the sugar be present in marked quantity, must be regarded as almost a positive bar to operation. In the condition of glycosuria, wounds have a tendency to remain open; they will not heal, and, still more, they are apt to run into spreading gangrene. This is notably the case if the lower extremity be the seat of the wound or operation. Here all attempts to arrest the diabetic gangrene commonly prove futile, and the disease spreads obstinately, slowly, and continuously, until the patient sinks from exhaustion.

Liver.—The liver is so intimately associated, both physiologically and pathologically, with neighboring organs, that it is somewhat difficult to define the precise limits, in surgical cases, over which its power is exercised. This much, however, may be said, that a diseased liver always increases the risks of operation, and favors the development of hemorrhage, inflammation, and constitutional septic poisoning. And this is so whether the case be one merely of torpid or inactive liver, or whether decided organic changes have already occurred. If the liver has undergone either fatty or amyloid enlargement, its evil influences are greatly augmented, and, before operation, careful examination should be instituted to ascertain the fact. The existence of a *fatty liver* may, indeed, be looked upon as an evidence of further internal mischief. It may be that the patient is suffering under some exhausting affection, or that he is, possibly secretly, intemperate. In *amyloid* or *waxy degeneration* of the liver, so often associated with splenic enlargement, renal albuminuria, and the syphilitic or tubercular cachexia, the prognosis of operations is unfavorable in the highest degree. In long-continued suppuration of bones, amyloid degeneration often occurs in the spleen, kidney, and liver, in the order mentioned, although either may be selected as its point of primary development, and sometimes nearly all the organs in the body are similarly affected. *Cirrhosis* of the liver, whether the result of alcoholism or other causes, exercises also a most deleterious effect on operative results. In fact, whenever the liver is diseased, no matter from what cause, it is a fair inference that the other organs adjunct to the portal circulation are more or less involved; and this must necessarily be so from the intimate and abundant vascular connection which exists between the liver and other abdominal viscera. The result will be portal disturbance, poor digestion, and imperfect assimilation—conditions which separately or in the aggregate promise badly for the success of the operator.

Bowel Affections.—The contra-indications to operation offered by the existence of *diarrhœa* and *dysentery* are so evident as to require but a passing mention. No surgeon would deliberately operate at such time, yet it occasionally happens that a patient, seemingly healthy, may die shortly after operation from the development of a fresh attack of obstinate chronic dysentery contracted years previously. This has always been the experience of military practice, and has been fully corroborated in the annals of our own military service. The writer has on several occasions known officers and soldiers, who had long since recovered, as they supposed, from the dreaded

Mexican or malarial dysentery, succumb to a fresh attack on the receipt of some slight injury, or the performance of some comparatively trifling operation.

CACHEXIÆ.—The influence of the different cachexiæ upon operations may be regarded from a twofold point of view. In the first place, as to the chances of immediate recovery from operations and the healing of wounds, and, secondly, as to the ultimate result. In regard to *scrofulous* patients, it is a matter of daily observation that they do well after operations. The removal of the source of irritation, the doing away with their chronic discharges, the relief from pain which they experience, all contribute to an improvement in their general health. If they are carefully watched and well nourished, and if their general hygiene and the ventilation of their rooms be attended to, their wounds of operation will heal—possibly slowly, sometimes not altogether perfectly, but still in some sort or other they close. The cicatrices of the scrofulous, as one would naturally suppose, are poorly organized, and have a tendency to open, if the diathesis continues to exert its force; the latter, too, may give fresh evidence of its power in other parts. The previous training of suffering which scrofulous patients have undergone stands them at this time in good stead. They bear confinement well if it is not too prolonged, and seem to be exempt from the influence of septic poisons which sweep away healthier persons. The influence of *tuberculosis* has already been alluded to in the remarks upon pulmonary disease. The general rule there laid down, that operative interference should be confined to cases of quiet and suspended phthisis, is equally applicable, with a change of terms, to the general diathesis. In short, operation should only be attempted when without it the patient must die, and when the removal of the source of irritation is attended with less immediate danger to life than its retention.

Constitutional *syphilis* undoubtedly in many cases influences unfavorably operative results, but, at the same time, it need not be considered as absolutely forbidding operation. There is probably in such cases a tendency greater or less to secondary hemorrhage, in consequence of the predisposition to disease of the walls of the larger arteries; and this must be borne in mind in applying the ligatures. The wounds made in syphilitic subjects do not always heal kindly; primary union is sometimes difficult, or, if partially effected, the adhesions may break up suddenly and apparently without sufficient cause. Hence it happens that plastic operations, particularly on parts in the vicinity of the genital region which have been the seat of previous destructive processes, are often unsuccessful, and that attempts to close fistulæ and losses of substance are commonly of no avail.

Operations upon *cancerous* patients are constantly performed where necessity commands, and there is no reason why they should not be done. These wounds heal readily, and there is no evidence to show that the constitutional condition of the patient is rendered more unfavorable. The question in such cases is simply one of expediency, and the surgeon must decide from a careful consideration of the circumstances surrounding each individual at the time.

The *gouty* and *rheumatic* diatheses are supposed to act in a measure as contra-indicating operations. As far as they impair the strength of the patient, this is so; and no one would willingly select the period of an attack of gout, or of the acute febrile stage of rheumatism, as the time of operation. As is well known, in gouty persons, any constitutional disturbance may give rise to a fresh attack. In rheumatic patients, the tendency to cardiac complications, and the possible exacerbations of existing disease by operative interference, must always be borne in mind. The *lithic acid* diathesis is likewise unfavorable to operation, since it is usually accompanied by impaired

bodily strength and by deranged action of the kidneys. Operations during an attack of *erysipelas*, or through tissues already affected by that disease, must not be practised if they can possibly be avoided. They may only be attempted in extreme cases, and where no other means of saving life are available. Under such circumstances, the most active stimulant and tonic treatment, and the free exhibition of iron preparations, should be carefully pressed. *Cutaneous eruptions* not unfrequently occur as the sequence of operation. Allusion has already been made to the scarlatina of children. Urticaria is often consequent upon operations on the genital organs, and erythema, sometimes of a very intense type, is not unusual. Erysipelas need only be mentioned in this connection, forming, as it does, in conjunction with disintegration and gangrene of the cellular tissue, one of the common causes of death after operation. Purpura and ecchymotic extravasations are evidences of blood-poisoning, and are not rare in depraved constitutions.

Conditions Connected with the Operation Itself.—There are certain conditions, incident to the performance of operations, accidents as it were, which greatly influence the result. One of the most potent of these is *pain*, which in itself is depressing and conducive to shock, especially in children, who so illy sustain it. Fortunately, the discovery of anæsthesia, perhaps the greatest blessing which has been conferred on suffering humanity, has deprived surgery of half its terrors, and the operator is seldom justified in attempting any serious operative procedure without resorting to it.

Hemorrhage, once the dread of the surgeon, has too in great part been overcome, and the importance of Esmarch's invaluable contribution of bloodless surgery cannot be overestimated. It is a mistake to suppose that bleeding is advantageous in operations, for it must be remembered that the blood is a fluid of complex formation, and that, once withdrawn from the body, its place cannot be readily supplied. The baneful effect of bleeding on children and in the old is very decided, and has much to do with the production of shock. The relative loss of blood is often the turning point, as to recovery or death after an operation. It is dangerous when it occurs as a primary accident, and even more so in its secondary forms. In the first case, it contributes directly to shock, and in the latter, indirectly to the predisposition to septic poisoning. It must therefore be carefully guarded against, as well at the time of operation as in the after conduct of the case. If it is evident during an operation that too much blood is being lost, and symptoms of exhaustion become apparent, the head of the patient must at once be lowered, to favor the access of blood to the brain. The respiratory efforts must be stimulated by the vapor of ammonia and cold aspersions, and, if the temperature of the body continue to fall, artificial heat must be applied. Excessive hemorrhage during operation is much to be dreaded when it occurs in patients who are already anæmic from any cause. In military practice secondary bleeding has often been too common, particularly in men who have been overmarched, and whose vital powers have been broken down by privation, nervous exhaustion, defective diet, and exposure to malarial and other depressing climatic causes. Under these circumstances, prolonged transportation in wagons and rude ambulances has proved most injurious by inducing bleeding; and the writer has known many a life thus lost, which might have been saved if the exigencies of war had only permitted the sufferer to rest in quiet near the scene of conflict.

Shock.—A powerful element in the production of shock is prolonged operation. In some instances, this would seem to be chargeable to the very state of anæsthesia. When a patient is insensible to pain, the surgeon may be tempted, perhaps unconsciously, to extend his operation over a longer period than is altogether judicious. Then too there is sometimes undue exposure of

the patient to draughts of air, and he becomes unnecessarily chilled; and full reaction, upon which so much depends, takes place slowly. The development of the shock of operation is thus favored. It may, however, result from the previous effects of mental depression. In one or two instances the writer has seen it brought about, or at all events greatly augmented, by fear; in fact, in one well-remembered case, from fear, carried to such a state of abject cowardice and demoralization as to lead to disastrous consequences on the reception of an insignificant wound. Surgical shock often accompanies large operations, or operations on internal viscera, and, as a rule, the more extensive the operation or mutilation, the more intense will be the resulting shock. It may, however, attend comparatively trifling wounds or injuries, and the writer has seen it present in an exaggerated form, in one instance, where the spermatic cord was merely grazed by a bullet. The *time of operation* has much to do with the result. Thus, as a rule, no operation ought to be attempted during the existence of shock, but the surgeon should watchfully await the period of reaction. Exceptions to this law, it is true, may arise from the absolute necessities of the moment; for example, a limb may be almost torn off by a shot, or piece of shell, or may be hopelessly crushed in a railroad accident, and its prompt removal may be demanded by uncontrollable hemorrhage, or reaction after injury may be tardy, and the state of shock be kept up by the presence of the mutilated member. Here immediate operation may be proper, and indeed necessary to release the patient from his depressed condition, and thus preserve life. The relative influence of *primary* and *secondary operations* must also be considered, particularly in military practice, and when coupled with the question of after transportation. *Intermediate operations*, or those practised during the existence of traumatic fever, and before the arrival of the true secondary fever, should be discountenanced; since errors of judgment in this respect have too often led to unfortunate results.

Local Condition.—The local condition of a part must always be carefully considered; and operations should not be performed through unhealthy tissues, or through those which are inflamed, sloughing, or gangrenous, or in which phlebitis exists. Neither should plastic operations be repeated too soon after previous failures in obtaining union, but sufficient time should be granted to the tissues involved to harden and return to their original state. Neglect of this precaution is almost sure to be followed by the cutting out of pins and sutures, and by failure to unite.

Hemorrhagic Diathesis.—There is one state of the system which greatly affects the question of operation; it is the existence of *hæmophilia* or the *hemorrhagic diathesis*. Fortunately this is not common, but still many cases have been recorded in which death has resulted, often after trifling operations, and for which the surgeon has been severely, and generally unjustly, blamed. It behooves him, therefore, to be on his guard, and always to make inquiry before operating, whether the peculiarity has ever been observed in the patient or his relatives, for the disease not unfrequently affects several members of a family, who are often spoken of as "bleeders." If the answer is an affirmative one, the utmost caution should be observed; or, better still, if the patient himself possesses this constitutional proclivity, no operation should be performed, unless life be at stake.

Condition of Patient after Operation.—The hygienic surroundings of the patient after operation, are of vital importance. If he is to be treated in a *private house*, it becomes the duty of the surgeon to see to these matters himself, and not to trust to the well meant but often badly executed inten-

tions of the family or friends of the patient. Every precaution must be taken to insure cleanliness in the widest sense of the term; a proper bed and bedding ought to be provided, and rubber cloths to prevent soiling by the discharges; all unnecessary hangings and draperies should be taken down as possible receptacles of dust, and of organic poisonous matters and emanations. The bed should be so placed as to be out of the way of draughts of air from doors and windows, and of direct currents of heat from hot-air flues, while at the same time convenient arrangements must be adopted to insure satisfactory ventilation, the temperature of the room being regulated by a thermometer. All excreta ought to be removed at once, and every means adopted to keep the room tidy, and the patient in as clean and comfortable a condition as possible. Disinfectants should be freely used, not only in the room, but about the patient, whose person, where no objection exists, should everyday be carefully sponged and dried without uncovering him unduly.

The hygiene of *hospitals* has of late years been made the subject of elaborate study, and is daily attracting more attention. In all well-ordered hospitals, the diet sheets are usually sufficient and well arranged, and the personal cares rendered by the attendants are properly watched. The great danger in all large hospitals is, however, that of overcrowding; of bringing too many patients under one roof. Not only ought this to be guarded against, but care should be exercised to see that the wards are not too large; from twenty-five to thirty beds is a quite sufficient capacity for any one ward. The amount of air space usually regarded as sufficient for surgical cases, is from fifteen hundred to two thousand cubic feet, with a floor area of from one hundred to one hundred and thirty or forty square feet for each patient. These figures are all very well as far as they go, but it is well to see that, even with full averages, the height of the ceiling is sufficient, not less than fifteen or sixteen feet. Different systems have been devised for bringing in fresh air, and getting rid of the foul air, by means of upward and downward currents, and by the use of steam fans. Such ingenious methods have doubtless gone far to purify hospital wards; at the same time there is reason to believe that the best system of obtaining ventilation and insuring perfect change of air is that which may be called the natural one, namely, by doors, windows, and open fireplaces. Ventilation and change of air during the night are strongly to be insisted upon, and the persistent efforts of hospital attendants to close up their wards tightly during the hours of sleep, ought to be watchfully anticipated and restrained. The population of large wards ought also to be vigilantly scrutinized, and too many suppurating cases should not be placed in one room. Patients with bad sloughing sores and putrid emanations had best be isolated when practicable, in order to prevent ward contamination, and every ward should from time to time be emptied and thoroughly cleansed and disinfected. In other words, no effort should be spared to preserve the purity of a ward, and to permit at all times the free access of fresh air, in itself the most thorough of all disinfectants. The importance of good hospital drainage must never be forgotten, and, in effecting this, proper measures ought to be taken to prevent the backing of sewer gas, which not unfrequently occurs from defective trapping. Such emanations are of the most deadly character, and are fearfully potent in giving rise to various forms of blood-poisoning. Mr. Erichsen, in his truthful and forcible remarks on the overcrowding of hospitals, has pertinently pointed out the baneful influences of deficient sanitary regulations, and has shown how cruel such a system is to patients, and how unjust to hospital surgeons; inflicting on the former an unnecessarily high rate of mortality, and on the latter an undue burden of anxiety and responsibility.

The subject of civil and military hospital construction and organization is

foreign to the present article. Yet it may be said that for military purposes the well-known pavilion system of hospitals, with a central building for administration, is probably the most perfect which can be designed. It has also been shown practically that the same system, with certain modifications, can be made applicable to the erection of civil hospitals when sufficient ground can be obtained. One advantage of this system is the possibility of its expansion to almost any extent, an important consideration in the foundation of hospital charities designed to meet the wants of rapidly-growing populations. The experience of our late war conclusively proved the advantages of the pavilion system of hospital construction, and the history of the magnificent and extensive pavilion hospitals, which then sprang up over our whole country, will remain forever as a memorial of the intelligence, zeal, and ready adaptability to circumstances, which characterized the services of our army medical staff. Perhaps in this connection it may not be amiss to refer to the excellent results which at that time attended operations treated in tent hospitals. As is well known, after severe battles, vast numbers of wounded were thrown upon the hands of the army surgeons. These patients were accommodated in division, corps, and general hospitals placed near the seat of action. These hospitals were composed of hospital tents, the number used being suited to the urgency of the occasion, and varying from ten or a dozen up to several hundred. Four or five or more of these tents were often pitched end to end, arranged in conformity with the lay of the ground, so as to form wards of proper size, which could be readily cared for and overlooked by the nurses and medical attendants. In winter weather and during the heat of summer, these tents were protected by the army tent-fly. In cold weather, the warming was accomplished by small iron wood-stoves. In many instances, where it was probable that the hospital would be in use for some time, board floors were laid down. Whether this was really an advantage or otherwise seemed at times questionable. Tents so furnished looked better, it is true, but were open to the objection of foul accumulations taking place beneath the floor. They were supposed to be more free from dampness, but this could usually be guarded against by proper trenching, and it is not impossible that the earth floor in itself was preferable from its inherent antiseptic qualities. During this period it was surprising to note how well operations did, and how rapidly convalescence took place under these simple arrangements, which, rough as they might seem to the unprofessional eye, were undoubtedly to be preferred to any form of barrack, or, indeed, permanent hospital.

Causes of Death after Operations.

Hemorrhage.—Death may occur during or after an operation from different causes, acting singly or in combination. It may result, in the first place, from hemorrhage; and the more rapidly this takes place, and the greater its amount, the more depressing and disastrous will be its effects. If it be very excessive, death may be almost immediate; but generally in operations, although bleeding may possibly be profuse, it is prolonged, marked by quantity rather than by rapidity, and by timely and vigorous effort it may be arrested. There are instances, too, where, although not great in extent, its effects may at the time be pronounced, and, in the end, fatal. This is apt to be the case in patients of broken-down constitution, and who are usually spoken of as bad subjects for operation. These fail to react, and either sink from exhaustion or fall ready victims to septic or intercurrent diseases. Fortunately, at the present day, death upon the operating table from bleeding rarely happens, since the resources of modern surgery have

placed in the hands of the operator so many and such ingenious means of preventing such an occurrence; at the same time, it is just possible that the very employment of some of these means of controlling the primary flow may predispose to its secondary occurrence. Thus, if Esmarch's upper bandage be drawn too tightly, it may by its pressure prevent bleeding from vessels of medium size, which it were well to ligate, so that on the removal of the constriction and on full reaction, after the patient has been carried to his bed, troublesome bleeding may set in. This fact must be remembered, and caution should be observed in regulating the pressure at the time of operation; and very careful search must be instituted for bleeding points. Secondary arterial hemorrhage may happen at any moment, from the hour of operation until the deep portions of the wound are healed. It may result from imperfect ligation, from enlargement of the vessels, from too rapid and great development of the collateral circulation, from sloughing, from atheroma of the arteries, or from premature falling of the ligatures. Secondary venous bleeding may take place from the backward flow of blood at points destitute of valves, either where the valves are normally deficient, or where they have become imperfect from disease; or bleeding may occur from veins where a varicose condition exists. And in this connection it may be said that there is no reason why the veins which bleed should not be tied in amputations. The risk of so doing is exaggerated; the writer has frequently practised such ligations, and has known many instances where others have pursued the same course with good results. Venous bleeding may also be caused after amputation by adhesive strips or bandages applied circularly around the stump, so as to produce too much pressure when swelling of the part has occurred. The danger of bleeding, let the cause be what it may, cannot be overestimated, constituting, as it so often does, the turning point in the case, and forming one of the factors in the production and maintenance of shock.

Shock.—The shock of operation, familiar to every surgeon, is usually the result of no single cause, but rather of several combined. Hemorrhage, anæsthesia, prolonged manipulation, chilling of the body consequent upon exposure to the air, and the operative lesion to the tissues, are alike concerned in bringing about the prostration which characterizes this state. Mental causes also exert no slight predisposing influence in the production of shock. There is scarcely any better preparation for a patient about to submit to operation than a bright, hopeful disposition; there is none worse than despondency and dread. Other things being equal, the chances of recovery in the former instance are far better than in the latter. Shock is usually attended by extreme depression of the nervous system and interference with the action of the heart. The skin is of a waxy-white pallor; there is loss of color in the face, and particularly in the lips; a cold clammy perspiration, with sweat-drops forming on the forehead; and a pinched and contracted expression of countenance. There is intense muscular prostration, loss of bodily temperature, feeble respiration, and, in extreme cases, relaxation of the sphincter muscles. The pulse becomes feeble and irregular, and sometimes cannot be detected at the wrist. If an anæsthetic has been used, it will be difficult to form an opinion of the condition of the special senses; but, if not, these will be found to be somewhat dulled and interfered with. Intellection may remain in part—ordinarily, however, accompanied by some degree of hebetude or bewilderment. In milder cases of shock, there are not unfrequently nausea and vomiting, the latter of which is usually followed by reaction. Where the shock is very great and prolonged, death occurs from cessation of the heart's action; and this may at times happen

as a purely nervous effect, independent of hemorrhage or the other lethal causes referred to.

Another cause of shock, of more common occurrence than it should be, is too prolonged or lengthy operation; and this must be carefully guarded against, particularly in childhood and old age—periods of life more than all others susceptible to depressing influences. Pain, if great or of long duration, either at the time of operation or afterwards, contributes not a little to prostration, and may weigh down the scale of life and death. Violence during operation, or roughness of manipulation, leading to bruising of delicate tissues, as the prostate gland and neck of the bladder, may produce disastrous consequences, and the more so if such efforts are persisted in for any length of time; and the same may be said of forcible extension of the knee-joint, a procedure too often fraught with fatal shock.

When, from any circumstance, a condition of sudden depression, prostration, or shock, is becoming apparent during or immediately following operation, the most active measures must be instantly resorted to. Hemorrhage must be stopped at once, even if the operation has to be temporarily discontinued; the patient's body must be elevated, and his head made dependent, so as to invite the flow of blood to the brain. With the same intent, the large arteries of the extremities may be compressed by tourniquets, so as for the time to cut off the vascular supply in this direction, and increase the amount available for the demands of the central organs. The anæsthetic should be immediately withdrawn, and the vapor of ammonia and that of nitrite of amyl employed for their stimulating effects. The temperature of the body should be kept up by the application of hot-water bottles and cloths to the trunk and limbs, and by the use of stimulating or hot-water enemata. If the loss of blood has been very severe, transfusion should be attempted. The success of this measure in chronic hemorrhages has been sufficiently great to warrant, and, indeed, command, its employment as an immediate resource in acute surgical cases, where of all others its happy influence may be expected. Any of the different processes may be resorted to, but caution should be observed as to the quantity of blood injected; not more than three or four ounces should be thrown in at first, and the effects of the operation carefully watched. Usually, if this has not been too long delayed, these are promptly marked by the stronger heart-beats and the improved character of the pulse. If blood cannot be readily obtained, intra-venous injections of milk or other fluids can be made, in the manner described in another part of this work. (See Article on Minor Surgery.) Hypodermic injections of ether may also be used as a substitute for transfusion, with excellent results.

Occasionally it happens that death after operation results from *secondary shock* or *exhaustion*. This is most frequently the case in old persons, or those of delicate constitution, or of impressionable temperament. In them the first reaction is apparently complete and satisfactory; the respiration and circulation seem good; they sleep; and there may be some return of appetite. These favorable appearances are, however, delusive and of short duration, for in a little while, it may be at the expiration of eight or ten hours, or perhaps even after two or three days, the patient becomes weaker and weaker, and slowly relapses into a condition of shock, from which he cannot be extricated, and which continues until death. Sometimes the patient's downward course is rapid, at other times very gradual. Usually, in these cases, the mind remains clear to the last, and the patient seems indifferent as to his condition. It is difficult to offer any explanation of the state of secondary shock, except on the idea of exhaustion of the heart, and the giving out of its power, dependent upon some of the causes already spoken of. Heart clot, formed during the

operation, is the pathological condition found in many of these cases, and its ill effects may be sometimes obviated by the free administration of ammonia, either by the mouth or by intravenous injection.

DELIRIUM.—Death may also take place after operation, or after injury, by the setting in of *delirium*, which usually presents itself as an acute affection in one of three forms. In the first place, it may appear as *acute traumatic delirium*, attended by symptoms of a highly inflammatory character. The pulse is then quick and full, the face flushed, the skin hot and dry, the eyes suffused, the restlessness and jactitation extreme, and the mental condition varying from incoherent babble and disjointed talk up to the most violent busy excitement. In another class of cases, and by far the most common, the affection is a true *delirium tremens*, characterized by all its well-known symptoms, tremors, delusions, and fancies. This form of delirium occurs in persons of intemperate habits, and in those who have been recently drinking. It is also met with in such as have been only moderate drinkers, and in those who have discontinued their habits in this respect for some time. The occurrence, after operation, of either of these forms of delirium is a most serious complication, and although many patients do recover from them, the prognosis is always grave, and not a few perish. One peculiarity of patients suffering from these invasions of delirium is their indifference to pain, and their constant tendency, and often persevering attempts, to do themselves bodily injury, by tearing off dressings, leaping from the bed, and inflicting violence upon themselves of every form. The treatment in such cases readily suggests itself. In the first place, such restraint must be enforced as is necessary, with constant watching; and for the acute inflammatory delirium, cold to the head, local depletion, and the cautious use of sedative narcotics. In the traumatic form of delirium tremens, the ordinary remedies for the treatment of this affection must be resorted to, such as bromide of potassium, capsicum, chloral, and opium, employed singly or in combination as may appear most appropriate. In many cases the hypodermic mode of medication will be the only one possible. The great indication is to procure sleep, and the therapeutic efforts in this direction must be steadily carried out until the result is obtained.

There is one other form of delirium after operation which is occasionally encountered. This is the *traumatic nervous delirium* observed in females of hysterical tendencies, and in persons of both sexes of broken-down constitutions, or in anæmic conditions. It is sudden of invasion, and is attended with mental hallucinations of almost every sort; usually of a quiet kind, but sometimes also of a noisy nature. This affection is one of weakness rather than of a true inflammatory nature; the pulse although frequent is feeble; the skin is not hot, but is often covered with a cold perspiration, and at times tremors are present. The prognosis in such cases is unfavorable, and death results in the majority of cases. The treatment consists in the employment of stimulant and soothing narcotics.

THROMBOSIS AND EMBOLISM.—Patients occasionally perish after operation from the formation of a heart clot, or from embolism; sometimes the coagula form in the large vessels, and then by their detachment give rise in turn to heart clot and secondary embolic plugging. There is always a predisposition to undue coagulation of the blood, after excessive bleeding, and this is greatly favored by the occurrence of fainting. The patient at these times must therefore be kept quiet, and cautiously moved, nor should he be allowed to sit up in bed, or to attempt any muscular exertion for fear of the development of fatal syncope.

Air in Veins.—Another accident from which death has been recorded is the entrance of air into a vein, following upon its incision during an operation. This circumstance ought to be borne in mind when large veins are involved, particularly in the deep portions of the neck, and when the tissues are infiltrated and indurated by disease. If a vein of any size be opened under these conditions, the lips of the wound may, on account of the tissue-connections of the vein, gape sufficiently to permit the entrance of air, and death may ensue, sometimes almost instantly. Whether the presence of air in the right heart paralyzes cardiac movement, or whether the air entering the branches of the pulmonary artery causes cessation of the circulation, is a matter for discussion; yet the great clinical fact remains, and enforces upon the surgeon the greatest caution in operating in these dangerous regions.

Gangrene and Sloughing.—Death after operations may occur, particularly in military practice, from the formation of sloughing sores, or the development of true hospital gangrene. The latter, in this country, has, however, been more rare than it is generally believed to have been; many of the cases described as such being in reality sloughing sores, not possessing the property of contagiousness. This was shown in a remarkable manner in our late war, where not a few cases of gangrene from the Libby and Andersonville prisons reached the northern lines. These possessed apparently all the destructive tendencies and evidences of hospital gangrene, but yet when placed in beds in general hospitals, under favorable hygienic conditions, the disease evinced little tendency to spread from bed to bed, or at all events to attack men who had not been exposed to the same predisposing causes, imprisonment, starvation, and exposure. The most effectual treatment for such cases consisted in ventilation, diet, and active cauterization of the sloughing surfaces with pure bromine, as suggested by Dr. M. Goldsmith, late Surgeon U. S. Volunteers.

Tetanus is another cause of death after operations. It may occur after slight operations as well as after those of great magnitude. Yet, in proportion to the whole number of cases, it is, at least in our climate, so infrequent that it may practically be disregarded in deciding upon the propriety of operation. Almost every imaginable circumstance has been advanced as an exciting cause of this terrible affection, as injuries, wounds, the presence of foreign bodies, verminous irritation, the arrest of natural or existing discharges, and exposure to heat or to dampness and cold. It has been the custom to lay stress upon the latter condition as a powerful causative agent in military practice. This is, however, probably incorrect. It is not the degree of cold which acts, but rather exposure to trickling or changing draughts of air, or, as Hennen has put it, to air in motion. The writer has known of instances where large numbers of wounded have at the same time been exposed to severe cold, without the development of a single case of the disease, while on the other hand, an instance was reported to him where two, if not three, consecutive cases of tetanus occurred in the same bed, every other one in the ward being exempt. The fatal bedstood in the direct draught of air between a window and an opening door, and on its removal to a less exposed position no further instance of the disease appeared. Tetanus at times almost seems to be epidemic, or at all events to affect many who are the victims of casualties of a given nature. Thus in the summer of 1880, frequent deaths from this disease occurred in Philadelphia, and during 1881, in Baltimore, from the use of a toy pistol, which exploded metallic powder cartridges. This dangerous plaything was the means of injuring numerous children by its premature and imperfect explosion. In almost every such case admitted to hospital, and in others treated in private practice, tetanus ensued and was followed

by death, the disease often making its appearance many days after the reception of the wound, and in some instances long after its closure and apparent healing.

Erysipelas is a not infrequent forerunner of death after operation, and must be regarded as a constitutional rather than as a local affection. It has long been the custom to look upon it as contagious ; but it is probable that this view is too exclusive. The doctrine is fast gaining ground that this disease is not really contagious, but that it is the result of a true septic poison depending on many circumstances. It, too, at times seems to be epidemic, occurring as it does, particularly in this country, during periods of rapid changes in the weather, and during atmospheric vicissitudes. It is apt to be induced by dampness and cold, and to make its appearance in persons of broken-down constitution. Its treatment is essentially a supporting one, and general tonics and iron are to be relied upon, rather than depleting agents. Closely allied to erysipelas, are those forms of diffused and spreading *cellulitis* and inflammation of the *veins* and *absorbents* so often observed in hospital, following wounds and operations, on those of debilitated constitution, and on drunkards. In many of these cases, surgical therapeutics avail little, and death from exhaustion ensues, after delusive intervals of hectic more or less prolonged. Indeed, exhaustion from long-continued discharges, whatever may be their origin, may be assigned as a not infrequent cause of the fatal termination of operations.

The disastrous influences of Pyæmia and Septicæmia require but a passing mention here, since they form the special subjects of another article. These forms of blood-poisoning are met with most often in patients of depraved system, or in the aged, or in those who have been broken down by overwork, mental or bodily. They cause a large proportion of the deaths after operations, and from their fatal consequences demand the closest study from the operating surgeon.

MINOR SURGERY.

BY

CHARLES T. HUNTER, M.D.,

DEMONSTRATOR OF ANATOMY IN THE UNIVERSITY OF PENNSYLVANIA; SURGEON TO THE EPISCOPAL HOSPITAL, PHILADELPHIA.

Surgical Dressings.

Surgical Dressings are generally considered to comprise various materials peculiarly adapted to protect wounds, absorb discharges, serve as vehicles for applying medicinal substances to wounded or diseased structures, aid in retaining injured parts in position, etc. The substances usually employed for these purposes include lint, charpie, tow, oakum, cotton, paper-lint, and jute.

Lint.—Two varieties of this material, domestic and patent, are used for surgical dressings. *Domestic lint* consists of pieces of old linen thoroughly cleansed either by being washed with soap and water, or boiled with a weak lye, and having one surface rendered downy by scraping up the threads, or cutting them at intervals, with a knife. Old linen, treated in this way, is peculiarly adapted to absorb secretions and to protect very delicate and sensitive surfaces.

Patent lint is manufactured in large quantities by machinery: hence it is more uniform in shape and consistence than the domestic variety, but much more expensive. This lint has a soft tomentose surface that renders it unsuitable for direct contact with granulating or wounded parts; for the fine filaments adhere to the granulations, and thus become a source of irritation. When thickly encased with some unctuous preparation, such as the oxide of zinc ointment, it forms an admirable protective covering.

Charpie consists of bundles of straight threads, varying in length from two to four inches, and obtained by ravelling square pieces of linen. Experience has demonstrated that charpie made from new linen is softer and possesses greater absorbent properties than that made from old. Charpie ought never to be placed on an unprotected granulating surface, or directly in contact with a recent wound, as is not infrequently done; in either case its presence will excite injurious irritation. Since the introduction of oakum and other less expensive materials as surgical dressings, charpie is not as much used as formerly, especially in hospitals and dispensaries where it is necessary to consult economy.

Tow is occasionally made use of as a padding for splints, and as an exterior dressing, but rarely as an application for uncovered wounds. An elegant preparation of carbolized tow has recently been introduced, and has been found to be serviceable in many ways.

Oakum was introduced as a cheap substitute for other more expensive surgical dressings, during the late American war, by Prof. L. A. Sayre,[1] of New York, and since then it has been very generally employed both in private and hospital practice throughout the civilized world. It is highly probable, however, that this substance has been often used for surgical purposes on board ship. In Pepys's diary, mention is made of a marine who had just returned from a severe naval engagement fought off the North Foreland, June 1–4, 1666, with "his right eye stopped with oakum." Oakum is believed to have antiseptic properties by virtue of the tar with which the pieces of old rope from which it is made are impregnated. Formerly this material was applied directly to the surface of wounds, but on account of the stiffness and coarseness of its fibres it has been found too irritating for this purpose. It is admirably adapted for use as an outer and protective dressing, and as padding for surgical apparatus.

Cotton, freed from its oleaginous principle by being boiled with alkalies or otherwise treated, is rapidly coming into favor as a surgical dressing. Prepared in this way, it quickly soaks up the secretions from a wound, and is preferred in many instances to oakum or marine lint as an outside absorbent dressing. It may be medicated with any of the popular antiseptics, such as carbolic, boracic, or salicylic acid, thymol, etc. Gynæcologists, in their practice, find it a useful means of making applications to the female genital organs.

Paper-Lint.—This dressing was first used for surgical purposes by Dr. Studdiford, of Lambertville, N. J. It is made from old rags that have been specially prepared and rolled in sheets of the requisite form and size. Dr. W. W. Keen, of Philadelphia, has suggested the incorporation of cotton or linen threads with paper-pulp, before it is rolled, in order that the lint may be rendered more tenacious. As an application to the unbroken surface of the body, and as an absorbent, external dressing, this variety of lint is quite as useful as patent or domestic lint; but, in consequence of its not possessing the softness and the pliability so characteristic of linen, it is not, as a rule, a good substitute for this material in the dressing of wounds. Its cheapness in comparison with the high cost of patent lint recommends it for hospital and dispensary use.

Jute.—This substance, of which gunny bags are made, is the fibre of an Indian annual, the *Corchorus capsularis*. In consequence of the peculiar character of its fibres, it is well adapted for the absorption and the retention of the various antiseptics; this property, and its cheapness in comparison with gauze and surgical cotton, have recommended its use as an antiseptic medium, to many of the advocates of Listerism. Jute may be employed with advantage as an absorbent dressing in all cases in which oakum or cotton is used; rolled loosely in small masses, it is considered in hospital and military practice a good substitute for sponges by those surgeons who believe that the use of these may result in the infection of wounds.

To meet a great variety of indications in the treatment of wounds, surgeons are accustomed to make the following forms of dressing from the substances already described.

Compresses are usually made by folding pieces of lint, flannel, paper-lint, or muslin, upon themselves, so as to form firm masses of varying size; these

[1] Boston Medical and Surgical Journal, vol. lxvii. p. 84.

may be made square, oblong, triangular, or graduated in shape. When a compress has a hole in its centre, it is termed a *perforated* compress; if there are many perforations, it is called a *cribriform* compress. A *pyramidal* compress is constructed by placing a series of square compresses, gradually diminishing in size, upon one another, in such a way as to form a pyramid. Oblong compresses arranged in the same serial order make a *prismatic* compress. A square piece of lint or muslin, slit from its angles towards the centre, forms a *Maltese cross;* an oblong piece, with slits extending from the angles of one side obliquely towards the opposite side, is called a *half* Maltese cross. These two forms of compress are found of service in covering the end of a stump, or in retaining dressings in contact with it.

The Pledget is a form of compress consisting of charpie, oakum, or jute, the fibres of which are arranged in a direction parallel to one another; after the ends are folded down, the mass is flattened between the hands, and fashioned into the required shape, either square, oblong, pyramidal, or graduated. Constructed in this manner, pledgets are applied as external dressings to wounds, extremities of stumps, and ulcers, for the purpose of absorbing discharges and excluding the air, and in some instances to make compression, and to aid in giving fixity to other dressings.

The Tent is a small roll of either of the substances referred to in the last paragraph, doubled upon itself, and made to assume a conical shape by twisting its free ends between the thumb and fingers. A strip of lint or muslin is often used for the same purpose. Tents made in this way are designed in special cases to keep wounds patulous, and thus to afford a ready escape to discharges. A tent should be introduced into a wound by a rotary motion, having previously been smeared with some bland, unctuous substance.

The Mèche is made by twisting a mass of parallel threads of charpie at the middle; if the threads are tied together with a string, the mass is called a Roll. These dressings, anointed with olive oil or simple cerate, and placed in the track of a sinus or fistula that has been laid open, will delay union of its edges till the deeper part has granulated. Hemorrhage from a deep wound may be checked by pressing a mèche or roll down to the bottom; the central part of the mass will compress the bleeding vessels, and the loose end will favor the formation of a clot. Mèches and rolls are introduced into a wound by means of a *porte-mèche* (Fig. 40), director, or probe, placed against the compact centre of the mass.

Fig. 40.

Porte-mèche.

Pellets and Bullets are small masses of charpie, oakum, cotton, or jute, rolled loosely between the palms of the hands. The former differ from the latter only in being inclosed in small bags of linen or old muslin. They may be usefully employed as tampons in cases of wounds, to check bleeding, and may be introduced into suppurating cavities for the purpose of absorbing pus and preventing burrowing.

Retractors are strips of muslin designed to protect soft tissues from being injured by the saw in amputations. *The retractor of two tails* is an oblong piece of muslin, ten to fifteen centimetres (four to six inches) wide, and thirty to forty-five centimetres (twelve to eighteen inches) long, with a slit extend-

ing from one extremity to the centre, where a diamond-shaped piece is cut out. *The retractor of three tails* is of the same size as the preceding, but has three tails instead of two. The former is used in amputations of the arm and thigh. After the flaps have been fashioned and the soft parts divided, the retractor is applied by passing the tails one on either side of the bone, and crossing them; then by drawing the tails up on one side and the body of the retractor on the other, the flaps are held out of the way of the saw, and protected from the bone-dust. The three-tailed retractor is employed in amputations of the forearm and leg; the middle tail is passed through the interosseous space, and the other two are carried around the bones.

To get the greatest advantage from the use of wet dressings, in cases in which heat and moisture are indicated, it is necessary that the dressings shall be covered with some material impervious to water. The following substances possess this property to a greater or less degree:—

Oiled Silk and Gutta Percha or Rubber Tissue, are the substances most commonly used in private practice; the former in this country and the latter in England. Although these two substances make the best water-proof covers for moist dressings, yet their great cost, and the supposed risk of their becoming media of contagion if used more than once, have led to the substitution of other less expensive articles, viz., waxed paper and water-proof paper.

Waxed Paper was first suggested and used in the Pennsylvania Hospital, by Dr. A. Hewson.[1] It is prepared by placing a sheet of tissue paper on the surface of melted wax in a broad, shallow pan, and, before the paper sinks in the wax, slowly drawing it over the edge of the pan, in order that the superfluous wax may be removed from its under surface. The sheets of paper thus treated are suspended on cords for a few hours in a cool place; after which they are ready for use. A sand-bath is employed to keep the wax in a liquid state.

Water-proof Paper.—Dr. W. W. Keen, of Philadelphia,[2] has devised a method of preparing paper by which it is rendered impervious to water and air. The paper is treated with a combination of rubber and paraffine which makes it impermeable to water for a period of seventy-two hours, and it may be used with the hottest dressing that can be borne. Unlike waxed paper, its water-proof property is not in the least affected by being creased or crumpled, nor will it absorb either water or the discharges from a wound. It is asserted by some surgeons that in hospitals where large quantities of water-proof material are concerned, it has been found more economical to use water-proof paper than oiled silk or rubber tissue, even when the former is not used a second time.

In order that wounds may be treated strictly antiseptically, two substances, made impervious both to the discharges from the wounds and to the surrounding media, are essential: one to protect the wound itself from contact with the dressing; the other to prevent putrefactive germs from gaining access to the dressing as it becomes saturated with the discharges.

The Protective.[3]—This material is to be placed in direct contact with the wound. It consists of oiled silk coated on both sides with a thin layer of

[1] Pennsylvania Hospital Reports, 1868, p. 389.
[2] Medical and Surgical Reporter, vol. xl., 1879, p. 331.
[3] MacCormac, Antiseptic Surgery, p. 135.

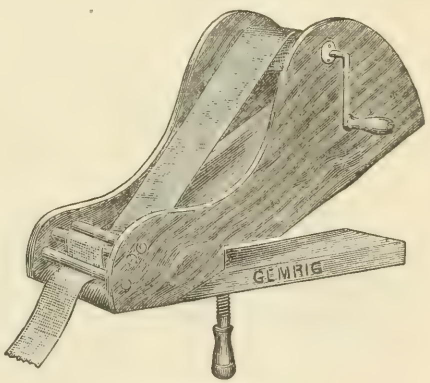
copal varnish, and, when dry, brushed over "with a solution containing one part of dextrine and two of starch, dissolved in fifteen parts of five per cent. carbolic solution." Immediately before using the protective, it is to be dipped in a 1–40 carbolic acid solution, in order that no germs may be left adhering to it. The same piece of protective may be used several times if it be properly disinfected.

MACKINTOSH.—This substance consists of cotton or silk, made impermeable to water and air by being coated on one or both sides with India-rubber. Other substances, among which are rubber-tissue and oiled paper, have been employed as substitutes for mackintosh, but they have proved less efficient. It is placed external to the gauze-dressing, and may be secured by a gauze-bandage, or by an elastic bandage, which Mr. Lister occasionally uses now. A piece of mackintosh may be repeatedly used, if care be taken to clean and disinfect it thoroughly each time that it is applied.

THE USE OF BANDAGES.

ROLLER BANDAGES.—The *Roller* consists of a band or strip of woven material, prepared for application to some portion of the body by being rolled into cylindrical form. The materials commonly used are unbleached muslin and flannel; for special purposes, however, linen, calico, silk, India-rubber, or crinoline, may be selected. It is desirable that a bandage should consist of a single piece, free from seams and selvage; yet bandages are sometimes made of several pieces sewed together. The latter should be avoided if possible whenever it is necessary to apply a bandage next to the integuments, for the seams (and the same is true of selvage) will leave creases in the skin. Bandages vary greatly in length and width according to the purposes for which they are employed, ranging from 2 to 10 centimetres ($\frac{3}{4}$ of an inch to 4 inches) in width, and from $18\frac{1}{5}$ to 91 decimetres (2 to 10 yards) in length. Bandages may be rolled by hand, or with a machine called a *winder* (Fig. 41), which is commonly used in hospitals where large quantities of bandages are consumed. In private practice a medical attendant may be called upon, at any moment, to roll a bandage; hence the art of rolling one by hand, which may be readily acquired with slight practice, should be familiar to every physician. In Fig. 42 is illustrated the way in which a roller is to be held in winding it by hand. A bandage rolled into the form of a cylinder is called a *single*, or *single-headed* roller (Fig. 43); if rolled from each extremity towards the centre, into two round masses, it forms a *double*, or *double-headed* roller. (Fig. 44.) The latter form of roller is hardly ever used.

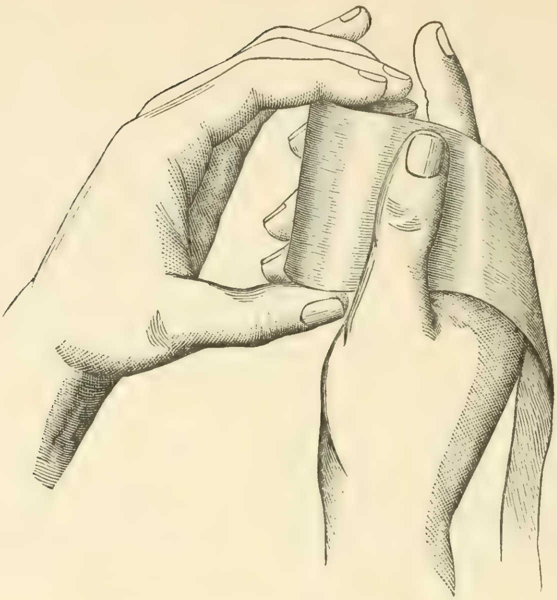
Fig. 41.



Bandage winder.

Parts of a Roller.—The free end of a roller is termed the *initial extremity;* the end inclosed in the centre of a roller is its *terminal extremity;* the portion intervening between the extremities, *the body;* a roller has two surfaces, *external* and *internal.* Bandages derive their names from one of two circumstances, either from the direction that they are made to take when applied,

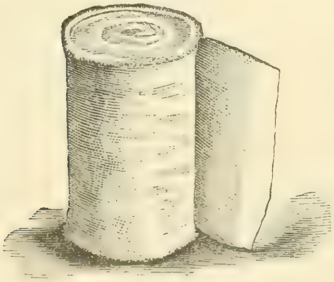
Fig. 42.



Mode of rolling a bandage by hand.

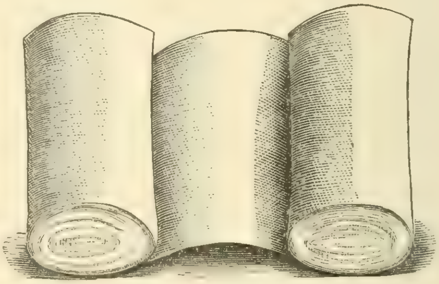
or from the purposes subserved by them. Thus there are *circular*, *oblique*, *spiral*, *spica*, *figure-of-eight*, and *recurrent* bandages of the first kind; and *retaining*, *compressing*, *uniting*, *dividing*, etc. of the second.

Fig. 43.



Single-headed roller.

Fig. 44.



Double-headed roller.

General Rules for Bandaging.—The operator, as a rule, should stand with his face towards his patient, and before he begins to bandage any part—a limb, for instance—he should see that it is in the position, as regards flexion and extension, which it is to occupy after the bandage is applied. In the application of a bandage, the external surface of the initial extremity should be placed next to the part to be covered; for then, as the bandage is unwound, it tends to roll into the operator's hand, thereby giving him more control of it.

To Secure a Bandage.—The initial extremity of a bandage is secured by two or three circular turns; the terminal end may be fastened by one or two pins, or by tearing it into two tails and tying them around the part. (See Fig. 49.) When pins are used to fix the terminal extremity, they may be introduced, either transversely to the bandage, with the point directed down-

wards, or longitudinally, with the point looking towards the body of the bandage; in either case the point should be buried in the bandage.

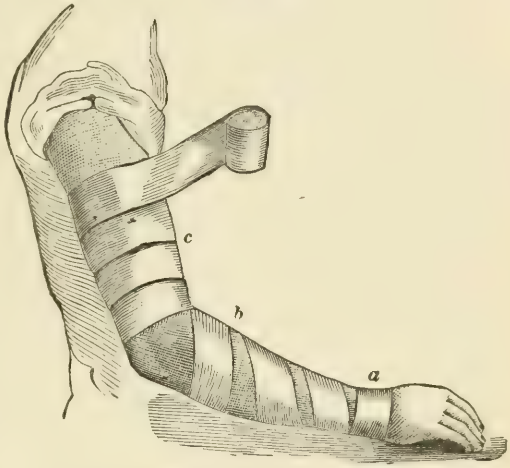
To Remove a Bandage.—In taking off a bandage, the folds should be carefully gathered up in a loose mass as the bandage is unwound; this will facilitate the process, and prevent the part from becoming entangled in the loops.

SPECIAL BANDAGES. *The Circular Bandage.*—This consists of a few circular turns around a part, each turn accurately covering in the whole of the preceding. (Fig. 45, *a.*) Its use is to retain dressings on some part of the vault of the cranium, and on the neck; and to compress the veins above the elbow, as a preliminary step in venesection.

The Oblique Bandage.—This bandage is carried by oblique turns up a limb, leaving uncovered spaces between the successive turns. It is used to retain temporary dressings. (See Fig. 45, *b.*)

The Spiral Bandage.—The turns of this bandage are carried around a part in a spiral direction, with each turn overlapping a portion of the preceding, usually one-third or one-half. (See Fig. 45, *c.*) This bandage is used for all the purposes for which that to be next described is employed, on parts the dimensions of which do not vary.

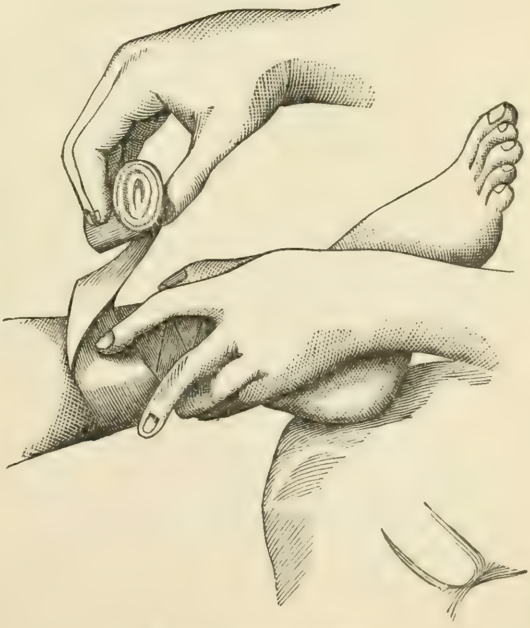
Fig. 45.



a circular, *b* oblique, and *c* spiral turns of bandage.

The Spiral Reversed Bandage.—This bandage differs from the preceding in having its turns folded back, or *reversed*, as it ascends a limb the diameter of which gradually increases. This modification of the spiral is of the utmost importance, for with it spiral turns can be applied to a limb conical in shape, so as to make equable pressure on all parts of the surface. Reverses may be formed in the following manner: After the initial extremity of a roller is made fast by a couple of circular turns, the roller is carried off ten or thirteen centimetres (four or five inches) from the limb, at an acute angle; the index

Fig. 46.

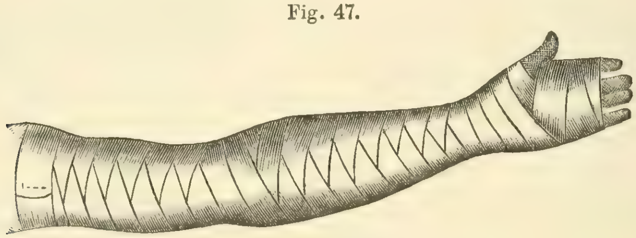


Mode of making reverses.

finger or thumb of the disengaged hand is put on the body of the bandage to keep it securely in place on the limb, while the reverse is being made; then the hand holding the roller is carried a little towards the limb, to slacken the unwound portion, and, by changing the position of this hand from extreme supination to pronation, the reverse is made. (Fig. 46.) A reverse must be completed before the bandage is continued round the limb; for if traction be made while the reverses are being formed, the bandage will be twisted and corded, and will consequently become a source of annoyance, if not of positive suffering, to the patient. For a bandage to present a neat and finished appearance, its reverses should be in line with one another. Reverses ought never to be made over a salient portion of the skeleton if it can be avoided.

SPIRAL BANDAGES.—*The Spiral Reversed of the Upper Extremity.*—A roller bandage $6\frac{1}{2}$ centimetres ($2\frac{1}{2}$ inches) wide and $6\frac{1}{2}$ metres (7 yards) long. First fix the initial extremity at the wrist by two circular turns; then carry the roller obliquely across the back of the hand to the second joints of the fingers, and surround them by a circular turn; ascend the hand as far as the thumb by one or two spiral turns; on reaching the thumb, cover its base and the wrist by two figure-of-eight turns carried above and below the thumb, and then continue up the forearm to the elbow by spiral reversed turns, made on the anterior aspect of the forearm. The elbow may be covered by spiral, spiral reversed, or figure-of-eight turns (passing above and below the joint, and named from their appearance), according to circumstances. When it is

Fig. 47.



Spiral reversed bandage of the upper extremity.

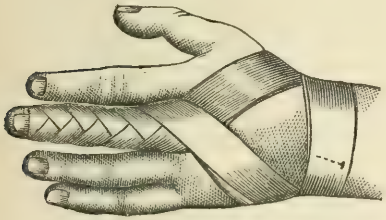
desirable to permit motion at this joint, the latter form of bandage is employed, and is applied with the joint somewhat flexed. To complete this roller it is conducted up the arm by spiral reversed turns to the margin of the axilla, where its terminal end is secured by a pin. (Fig. 47.)

The Spiral of a Finger.—A roller 2 centimetres ($\frac{3}{4}$ of an inch) wide and $1\frac{1}{8}$ metres ($1\frac{1}{4}$ yards) long. After securing the initial end by two circular turns at the wrist, conduct the bandage obliquely over the dorsum of the hand to the base of the finger that is to be covered; thence to its distal extremity by oblique turns; ascend the finger by spiral turns, and, on reaching its proximal end, carry the bandage obliquely across the back of the hand, and terminate it by a couple of turns around the wrist; either pin the extremity of the roller, or divide it in two tails and tie them around the joint. (Fig. 48.)

The Spiral of the Hand, or the *Demi-Gauntlet.*—A roller $2\frac{1}{2}$ centimetres (1 inch) wide and $2\frac{3}{4}$ metres (3 yards) long. The initial extremity is first secured by two circular turns around the wrist, after which the roller is carried from one side of the wrist to the opposite side of the hand obliquely across either the dorsum or the palm, the direction being determined by that surface of the hand which is to be covered; from this point the bandage is wound around

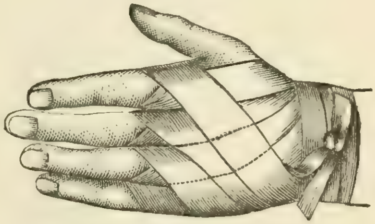
the base of the finger and taken back to the wrist, making a figure-of-eight of the finger and wrist. A figure-of-eight turn is made in like manner around the base of each finger and the wrist in succession, and the roller is finally fastened at the wrist. (Fig. 49.) This bandage is admirably adapted to confine dressings to either surface of the hand, as occasion may require; it is less cumbersome, and retains a dressing with more security, than any other means used for the same purpose.

Fig. 48.



Spiral bandage of a finger.

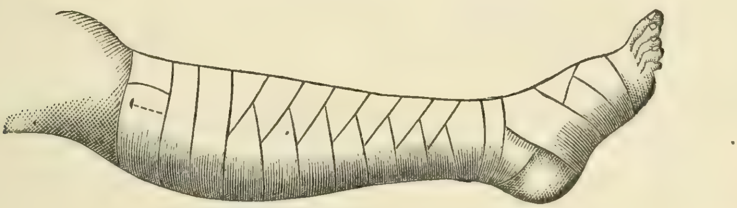
Fig. 49.



Spiral bandage of the hand, or demi-gauntlet.

The Spiral Reversed Bandage of the Lower Extremity.—Two rollers, each $6\frac{1}{2}$–$7\frac{7}{10}$ centimetres ($2\frac{1}{2}$–3 inches) wide and $6\frac{1}{3}$ metres (7 yards) long. The initial end being secured just above the malleoli by two circular turns, the roller is carried obliquely across the dorsum of the foot, and, on reaching the metatarso-phalangeal articulation, is conducted directly around the foot; the body of the foot is now covered by two spiral reversed turns and the same

Fig. 50.



Spiral reversed bandage of the lower extremity.

number of figure-of-eight turns, the latter being around the ankle and instep, and the roller is then continued up to the knee by spiral reversed turns, each turn covering one-third of the preceding; the reverses should be in a line on the outer side of the spine of the tibia. As in the case of the elbow, the knee may be covered by spiral, spiral reversed, or figure-of-eight turns. If it be designed to keep the knee flexed, the figure-of-eight turns should be employed. From the knee the roller is conducted up the thigh by spiral reversed turns, and is secured by pins. The second roller is used for the knee and the thigh. (Fig. 50.)

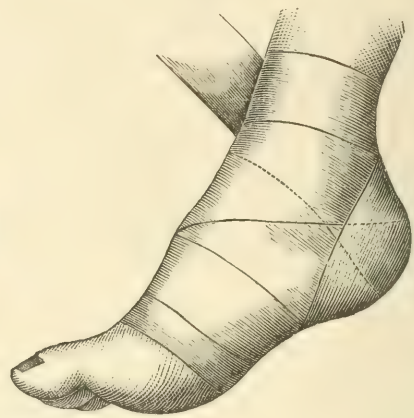
A modification of this bandage is occasionally employed to cover the heel, and is known as the *American Spiral* in contradistinction to that just described, which is sometimes called the *French Spiral.* The turns by which the heel is included are made in the following manner: After the foot is covered by two or three spiral turns, the bandage is carried directly over the point of the heel, across the tarsal portion of the foot, thence beneath the instep, around one side of the heel and up over the instep again; from this point it is conducted beneath the instep, around the other side of the heel and up

in front of the ankle, from which it may be made to ascend the leg, as in the preceding bandage. (Figs. 51, 52.)

The Spiral Bandage of the Chest.—A roller $7\frac{4}{5}$–9 centimetres (3–$3\frac{1}{2}$ inches) wide, and $9\frac{3}{20}$ metres (10 yards) long. Make two circular turns around the

Fig. 51.

Fig. 52.

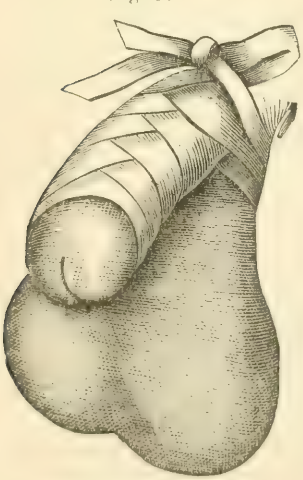


American spiral of the lower extremity.

waist, to secure the initial extremity of the roller, and then ascend the chest by spiral or spiral reversed turns, each turn overlapping one-third of the preceding; when the borders of the axillæ are reached, conduct the roller around the base of the neck, or through one axilla and over the corresponding shoulder, obliquely down the anterior aspect of the thorax. If this longitudinal strip be pinned or stitched to the spiral turns at their intersections, the bandage will not be easily disarranged.

The Spiral Bandage of the Penis.—A roller 2 centimetres ($\frac{3}{4}$ of an inch) wide and $\frac{3}{4}$ of a metre (30 inches) long. Secure the initial end of the roller by two circular turns around the penis, close to the pubes, and conduct the bandage by oblique turns to the corona glandis; from this point ascend the body of the penis by spiral or spiral reversed turns; then make two or three figure-of-eight turns around the neck of the scrotum and the root of the penis, and secure the terminal extremity by dividing it in two strips and tying them around the root of the penis. (Fig. 53.) The terminal figure-of-eight turns of this bandage keep it securely in position, and thus render it a very useful means of compressing the urethra over a catheter or bougie, in cases of obstinate hemorrhage from the penile portion of this canal.

Fig. 53.

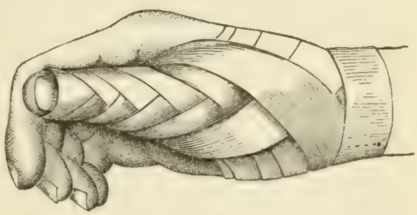


Spiral bandage of the penis.

Spica Bandages.—These bandages are exceedingly serviceable as a means of retaining surgical dressings on particular parts of the surface of the body, for which the spiral rollers are not well adapted. They derive their name from their fancied resemblance to a spike of barley.

The Spica Bandage of the Thumb.—A roller 2 centimetres ($\frac{3}{4}$ of an inch) wide and $2\frac{3}{4}$ metres (3 yards) long. Fasten the initial extremity by one or two circular turns at the wrist, then carry the roller obliquely over the dorsum of the thumb to its distal extremity, and there make a circular turn; from this point conduct the roller obliquely over the back of the thumb to the wrist, around which make another circular turn; then carry the bandage in a figure-of-eight form around the thumb and back again to the wrist. These turns overlapping one another by half or two-thirds of their width, are repeated till the whole length of the thumb is enveloped. (Fig. 54.)

Fig. 54.



Spica bandage of the thumb.

The Spica Bandage of the Shoulder.—A roller $6\frac{1}{2}$ centimetres ($2\frac{1}{2}$ inches) wide and $6\frac{2}{5}$ metres (7 yards) long. Fix the initial extremity by two circular turns around the arm just below the margin of the axilla; carry the roller from the outer surface of the arm, if on the right side, obliquely across the front of the chest; if on the left side, obliquely over the back; through the opposite axilla and back to the shoulder from which the bandage was started, thereby completing the first spica; then conduct the roller around the arm of this side, up over the shoulder, across the thorax, through the axilla the second time, and back to the shoulder again. Repeat the turns in like manner, over the shoulder and through the opposite axilla, till the former is covered; after which conduct the terminal end around the neck and down the front of the chest where it may be secured by a pin. Where the turns of the bandage intersect on the shoulder, they should overlap one another to the extent of one-third of their width; in the opposite axilla, however, they should completely cover one another. (Fig. 55.) When the intersections or spicas advance successively from the point of the shoulder to the base of the neck, the bandage is called the *ascending spica*. If the succession of the spica be in the reverse direction, that is, from the neck towards the arm, the roller is termed the *descending spica*. Small masses of cotton, oakum, or jute, should be interposed between the borders of the axilla and the turns of the bandage to prevent excoriation.

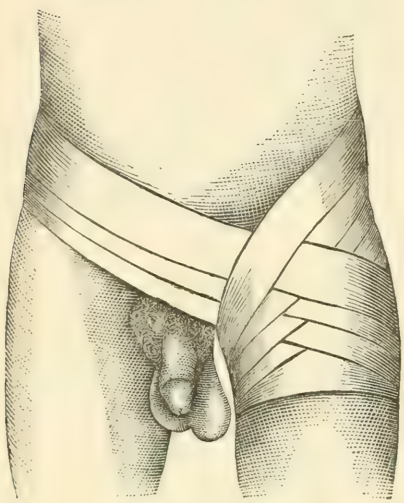
Fig. 55.

Spica bandage of the shoulder.

The Spica Bandage of the Groin.—A roller $7\frac{4}{5}$ centimetres (3 inches) wide and $9\frac{1}{6}$ metres (10 yards) long. Secure the initial end by two circular turns around the body, just above the pelvis; then carry the roller obliquely downwards across the lower part of the abdomen, either to the outer side of the

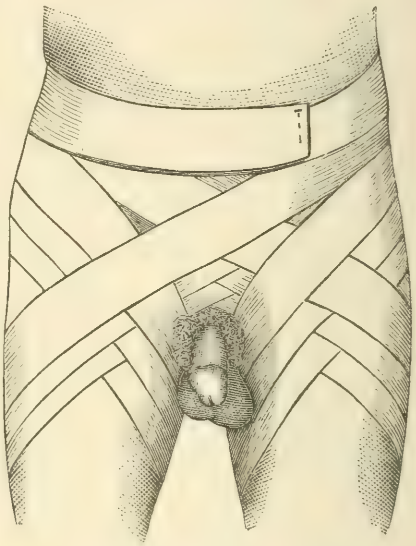
left thigh, or to the inner side of the right, as the case may be; thence around the thigh, obliquely upwards, crossing the preceding turn, and around the body. Continue these turns around the thigh and abdomen, either in an ascending or a descending order as regards the thigh, till the roller is exhausted. Each turn around the thigh should overlap that immediately preceding by one-third of its width. If the intersection of the turns on the anterior surface of the thigh and the groin be from above downwards, a *descending spica* will be formed; if they be in the reverse direction, that is, from below upwards, an *ascending spica* will be made. (Fig. 56.)

Fig. 56.



Spica bandage of the groin.

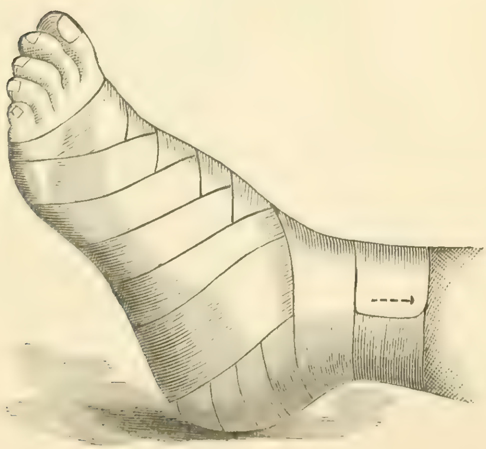
Fig. 57.



Spica bandage of both groins.

The Spica Bandage of both Groins.—Two rollers, each $7\frac{4}{5}$ centimetres (3 inches) wide and $6\frac{2}{5}$ metres (7 yards) long. This bandage is begun like the preceding, by two circular turns above the ilia, after which a spica turn is made, as above described, first on one thigh and then on the other, either in an ascending or a descending series. (Fig. 57.)

Fig. 58.



Spica bandage of the foot.

The Spica Bandage of the Foot, sometimes called Ribbail's Bandage. A roller 5 centimetres (2 inches) wide and $6\frac{2}{5}$ metres (7 yards) long. Make fast the initial end of the roller, laid obliquely upwards on the dorsum of the foot, by a circular turn around the metatarso-phalangeal articulation, and one or two spiral reversed turns around

the metatarsus; then carry the bandage parallel with the inner or outer margin of the sole of the foot, according to whether it be the right or left foot, directly across the posterior surface of the heel, thence along the opposite border of the foot and over the dorsum; this completes one spica turn. From the dorsum the bandage is made to encircle the foot and pass around the heel and over the foot the second time, thereby forming another spica on the foot. By continuing these successive turns around the foot and the heel, each complete turn overlapping one-half or two-thirds of the preceding, in an ascending order, the entire foot and ankle are covered. (Fig. 58). In all cases in which firm compression of the foot is indicated, as in bruises, chronic sprains, wounds of the tibial vessels, etc., this neat bandage will be found of great advantage.

FIGURE-OF-EIGHT BANDAGES.—*The Figure-of-Eight Bandage of the Elbow.*—A roller $6\frac{1}{2}$ centimetres ($2\frac{1}{2}$ inches) wide and $1\frac{2}{5}$ metres ($1\frac{1}{2}$ yards) long. Fix the end of the roller by two circular turns around the upper part of the forearm, then carry it obliquely across the bend of the elbow to the arm, above the inner or outer condyle according to the direction taken, thence over the posterior surface of the arm to the opposite side, and across the front of the elbow again, to the point from which the roller started. These turns are repeated, making those above the joint overlap the lower thirds of the preceding turns, and those below, the upper thirds, till the point of the elbow is reached; then complete the envelopment of the joint by a circular turn carried over the olecranon process. This bandage, when it does not form a constituent part of the spiral reversed of the upper extremity, is principally used to retain a compress or other dressing on the wound made in venesection at the bend of the elbow.

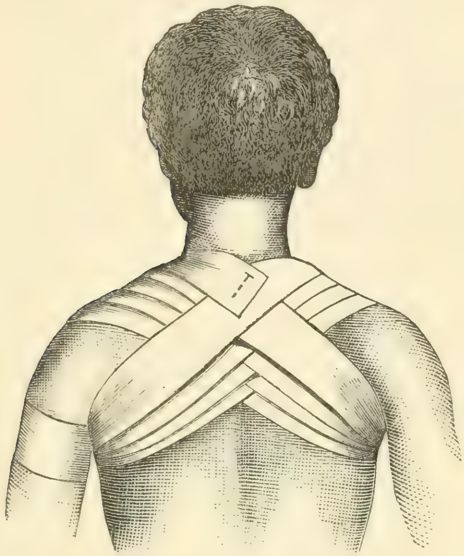
The Anterior Figure-of-Eight Bandage of the Chest.—A roller $6\frac{1}{2}$ centimetres ($2\frac{1}{2}$ inches) wide and $6\frac{2}{5}$ metres (7 yards) long. Make fast the initial extremity by two circular turns around the upper part of the right arm, after which carry the roller over the shoulder, obliquely across the front of the thorax, through the left axilla, over the shoulder of the same side, thence back across the front of the chest (intersecting the preceding turn over the sternum) through the right axilla, and up to the top of the shoulder. Repeat the figure-of-eight turns on the anterior face of the chest, till the bandage runs out, and pin the terminal end. The borders of both axillæ should be protected from excoriation by compresses of cotton or jute, inserted between them and the turns of the bandage. (Fig. 59.)

Fig. 59.

Anterior figure-of-eight bandage of the chest.

The Posterior Figure-of-eight Bandage of the Chest.—A roller $6\frac{1}{2}$ centimetres ($2\frac{1}{2}$ inches) wide and $6\frac{2}{5}$ metres (7 yards) long. Secure the initial end of the roller on the upper part of the left arm by two circular turns, then conduct the bandage over the shoulder, obliquely across the back, through the opposite axilla, over the shoulder of the same side, obliquely across the posterior surface of the thorax (crossing the previous turn between the scapulæ), through the left axilla, and up to the summit of the shoulder, from which similar turns across the back and through the axilla are to be repeated till the bandage is exhausted. (Fig. 60.) The same precautions against excoriation of the borders of the axillæ are to be adopted as in the case of the preceding bandage.

Fig. 60.



Posterior figure-of-eight bandage of the chest.

The Suspensory and Compressor Bandage of the Breast. — A roller $6\frac{1}{2}-7\frac{4}{5}$ centimetres ($2\frac{1}{2}-3$ inches) wide and $7\frac{3}{10}-9\frac{3}{20}$ metres (8–10 yards) long. Make fast the initial end of a roller, placed over the scapula of the affected side, by two oblique turns carried over the opposite shoulder, under the affected mamma, and through the axilla of the same side; from this point conduct the roller transversely around the chest, covering the lowest portion of the gland in its course. Continue making oblique turns of the shoulder and axilla, alternating with circular turns of the chest, each of the respective turns overlapping the upper part of the preceding by about one-third, till the affected breast is completely covered by oblique and circular turns. (Fig. 61.)

Fig. 61.

Suspensory and compressor bandage of the breast.

Fig. 62.

Suspensory and compressor bandage of both breasts.

The Suspensory and Compressor of both Breasts.—Two rollers, each $6\frac{1}{2}$–$7\frac{4}{5}$ centimetres ($2\frac{1}{2}$–3 inches) wide and $6\frac{3}{5}$ metres (7 yards) long. Secure the initial end by two oblique turns of the shoulder and the axilla, as in the preceding bandage; then carry the roller transversely across the back, up under the breast and over the shoulder, thence obliquely downwards over the back and towards the other side, and transversely around the front of the chest (covering the lower part of both breasts) to the point of beginning on the back. Continue the application of the roller first by an oblique turn of one shoulder and the opposite axilla, then of the other axilla and the opposite shoulder, followed by a circular turn of the front of the thorax. Each turn, both of the oblique and of the circular series, should overlap one-third of the preceding in an ascending order, till both breasts are covered by oblique and circular turns. (Fig. 62.)

Velpeau's Bandage.—Two rollers, each $6\frac{1}{2}$ centimetres ($2\frac{1}{2}$ inches) wide and $6\frac{3}{5}$ metres (7 yards) long. Let the patient place the hand of the affected side on the opposite shoulder, then apply the initial end of a roller on the body of the scapula of the sound side, and secure it by two turns made by conducting the roller over the shoulder of the affected side, down the outer and posterior surface of the arm of the same side, behind the point of the elbow, thence obliquely across the front of the chest and through the axilla of the sound side to the point of beginning. From this point, carry the roller in a transverse direction around the thorax, passing over the flexed elbow of the affected side, thence through the axilla to the back. Carry the roller again over the shoulder, down the outer and posterior surface of the arm, behind the elbow, obliquely across the front of the chest, through the axilla of the sound side, and thence around the chest and arm. The application of the oblique and circular turns is continued in like manner till the flexed arm is firmly bound to the anterior surface of the chest. The turns running over the shoulder and winding round the outer and posterior surface of the arm, should advance towards the point of the elbow by each overlapping *two-thirds* of the preceding turn; the circular turns should ascend the arm and chest from the point of the elbow by each covering *one-third* of the preceding turn. (Fig. 63.)

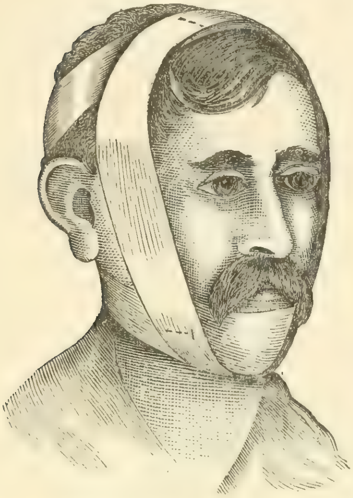
Fig. 63.

Velpeau's bandage.

BANDAGES FOR THE HEAD.—*The Figure-of-eight Bandage of the Head and Jaw.*—This bandage is commonly called Barton's bandage. A roller 5 centimetres (2 inches) wide and $4\frac{1}{2}$ metres (5 yards) long. When this bandage is used for fracture of the lower jaw, its initial extremity is placed on the head just behind the mastoid process of the sound side, and is carried under the occipital protuberance, obliquely upwards, under and in front of the parietal eminence, across the vertex, down the side of the face on the sound side, beneath the jaw, thence up along the side of the face, over the top of the head (passing over the other turn in the median line), under the parietal eminence to the point of commencement. It is then conducted under the occipital protuber-

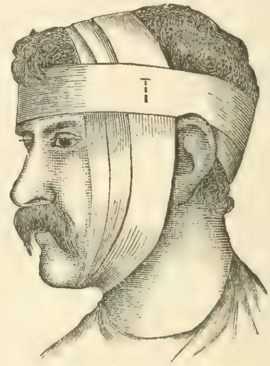
ance, forward under the ear and in front of the chin, and thence back to the point from which the roller started. Continue to make the figure-of-eight turns over the head and the circular turns around the base of the skull till the bandage is exhausted. Each turn should completely cover the preceding, so that the bandage when applied should look as if it were formed of single turns. In order that the bandage may not be easily displaced, the different intersections should be pinned. (Fig. 64.)

Fig. 64.



Barton's bandage.

Fig. 65.



Crossed or oblique bandage of the angle of the jaw.

The Crossed or Oblique Bandage of the Angle of the Jaw.—A roller 5 centimetres (2 inches) wide and $4\frac{1}{2}$ metres (5 yards) long. Make fast the initial end of the bandage by two circular turns around the vault of the cranium, going from left to right, if it is designed to cover the left angle of the lower jaw, and *vice versa* if the right angle. On reaching the back of the head, conduct the bandage obliquely across the nape of the neck, under the ear and the jaw on the sound side to the angle on the affected side, thence up over the face in a line half way between the eye and the ear, obliquely across the top of the head, and down behind the ear of the sound side; from this point carry the bandage again under the jaw and up over the side of the face, making it overlap the posterior two-thirds of the preceding turn, thence obliquely across the top of the head, down behind the ear of the sound side, and again under the jaw and up over the face, covering the posterior two-thirds of the second upward turn. When the intersection of the circular and the descending turns is reached on the sound side, reverse the bandage and terminate it by two circular turns around the head. (Fig. 65.)

This bandage will be found useful for retaining dressings on the side of the face in cases of wounds of the parotid region. When employed in the treatment of fracture of the ramus and neck of the lower jaw, an oblong compress should be placed between the seat of fracture and the ascending turns of the bandage.

The Recurrent Bandage of the Head.—A roller 5 centimetres (2 inches) wide and $4\frac{1}{2}$ metres (5 yards) long. Secure the initial extremity of the roller by two circular turns around the forehead and occiput; on reaching the middle of the forehead or the occipital protuberance, reverse the roller and carry it over the top of the head to a point directly opposite, where it is again reversed or turned back, and conducted back over the vertex to the point of commence-

ment, overlapping one-third or one-half of the preceding turn. These recurrent turns over the summit of the skull are repeated till the top of the head is entirely covered, after which the bandage is reversed and two circular turns are made around the vault of the cranium, to secure the ends of the recurrent turns just above the root of the nose and below the occipital protuberance. (Fig. 66.) While this bandage is being applied, one extremity of the recurrent turn must be kept in position either by an assistant or by the patient; the other extremity may be retained by the surgeon himself, till they are made fast by the terminal circular turns.

Fig. 66.

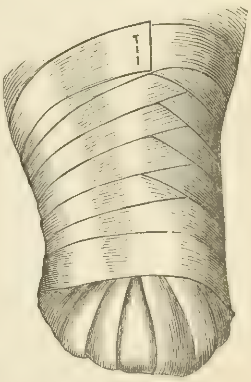
Recurrent bandage of the head.

Fig. 67.

V-bandage of the head.

The V-bandage of the Head.—A roller 5 centimetres (2 inches) wide and $3\frac{3}{5}$ metres (4 yards) long. Secure the initial extremity of the roller by two circular turns around the vault of the cranium, and, on arriving at the back of the head, conduct the roller forward under the ear, over the upper or lower lip, as the case may be, and backward on the opposite side of the head to the occipital protuberance. Then make alternate turns around the base of the cranium and the front of the face, and terminate the bandage by pinning it at the intersection of the turns on the occiput. (Fig. 67.) This bandage was suggested by the writer for the purpose of retaining dressings on the lip or the front of the chin, in cases of wound of those parts. In consequence of the direction of its turns, this bandage offers no obstruction to the patient opening his mouth, which is not the case with Barton's bandage when it is used to meet the same indications.

Fig. 68.



Recurrent bandage for stumps.

Other Roller Bandages.—*The Recurrent Bandage for Stumps after Amputation.*—A roller 5–$6\frac{1}{2}$ centimetres (2–$2\frac{1}{2}$ inches) wide and $4\frac{1}{2}$–$6\frac{1}{2}$ metres (5–7 yards) long. After securing the initial end of the roller by two circular turns around the stump, a few inches above its extremity, reverse the bandage on the under or posterior surface of the stump, and conduct it over the extremity to a point opposite, on the upper aspect, thence back over the end of the stump to the point of beginning. Repeat these recurrent turns, each turn overlapping the preceding by one-third or

one-half of its width, covering first one half of the end of the stump and then the other, after which make two circular turns, to fix the extremities of the recurrent turns. If considered necessary, the stump may now be enveloped by spiral or spiral reversed turns made in the usual way. (Fig. 68.)

In addition to the foregoing roller bandages, another variety, denominated the T-bandage, is occasionally used to retain dressings. The simplest form of the T-bandage consists of two strips of muslin, one a transverse piece, sufficiently long to pass once or twice around the part to which it is to be applied; the other, a longitudinal piece, which is sewed at right angles to, and at the middle of, the transverse piece. The longitudinal piece should be, as a rule, about half the length of the other. When two longitudinal strips are attached to the transverse piece, the double T-bandage is formed.

The *Single T-bandage* is sometimes applied to the head, to keep dressings on the scalp. In applying it to this portion of the body, the transverse piece is carried around the vault of the cranium, and the longitudinal strip taken over the summit of the head and beneath the transverse strip on the opposite side; it is then turned back on itself and pinned. When it is necessary to cover a considerable surface of the scalp, the longitudinal piece may be made of sufficient width to meet the particular indication. If the free end of the longitudinal piece be slit into two tails for about two-thirds of its length, the single T-bandage becomes a useful means of keeping dressings on the perineum after operation, as in cases of fistula and abscess in this region. When this form of T-bandage is applied to the perineum, the transverse piece is secured around the body, just above the pelvis, while the longitudinal piece is brought down between the nates, and its tails, separated so as to pass on either side of the genitals, are carried obliquely upwards and outwards and fastened to the transverse piece. Another modification of the single T-bandage is employed for the ear. The modification consists in attaching one end of an ear-shaped piece of muslin to the centre of a transverse strip; to the other extremity of the ear-shaped piece is sewed a longitudinal strip. If it is designed to retain a dressing on the surface of the head immediately around the ear, a slit is made in the ear-shaped piece, through which the auricle passes.

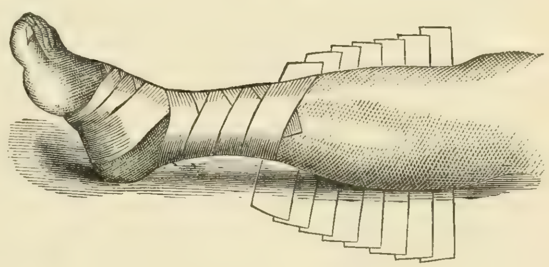
The *Double T-bandage* is a convenient means of retaining a dressing on the nose. In its application, the portion of the transverse strip intervening between the attachments of the longitudinal pieces, is placed on the upper lip below the nose; the longitudinal pieces are then brought up along the sides of the nose to its root, where they cross each other; thence they pass over the top of the head, and are secured by the extremities of the transverse strips which are carried around the head. The double T-bandage consisting of a broad transverse piece of muslin with two narrow longitudinal strips sewed to its upper border, is the best bandage in use for retaining dressings on the chest, especially after operations on the mamma. The transverse piece should be about 20½ centimetres (8 inches) wide, and long enough to pass one and a quarter times around the thorax. The two longitudinal strips, each about 5 centimetres (2 inches) wide and 51 centimetres (20 inches) long, should be attached to the transverse piece, a short distance apart, one on either side of its middle. The transverse piece is carried around the chest and pinned in front; the longitudinal strips are brought directly over the shoulders, and secured by pins to the upper margin of the broad piece.

Another form of bandage, termed the *Sling*, is occasionally found serviceable in cases of fracture of the lower jaw, and in keeping dressings on the nape of

the neck, the chin, or other parts of the body. To make a *sling*, or *four-tailed bandage*, take a piece of broad bandage, long enough to encircle the part to which it is to be applied and to overlap a little, and split both ends towards the centre. The central portion of the piece thus treated is called *the body;* the extremities the *tails.* To apply the four-tailed bandage to the nape of the neck, place the body directly over the dressing which it is designed to retain, and carry the upper tails around the forehead and the lower tails around the neck, where they may be secured by pins. A similar bandage may be used as a temporary support in cases of fracture of the lower jaw. The body of the bandage is placed beneath the chin, and the upper tails are directed backward below the ears, towards the occiput; before securing these, the lower tails are carried up the sides of the face, crossed on the vertex and secured by pins where they terminate. The lower tails are then crossed below the occipital protuberance, and brought above the ears towards the forehead, where they are pinned together.

The Many-tailed Bandage, or the Bandage of Scultetus, is a convenient dressing in some cases of compound fracture or severe wounds; for, after it has been once applied, it can be renewed without disturbing the affected part. It is made by cutting a roller bandage into the requisite number of pieces, each long enough to go around the part and overlap 5–7½ centimetres (2–3 inches). These pieces are disposed in such a way, under the part, that the first piece shall be overlapped by the second, the second by the third, and so on, from below upwards; the extremities of the last piece are secured by pins. (Fig. 69.) Whenever it is necessary to change strips that have become soiled, it can be readily done, without raising the limb, by pinning fresh pieces of bandage to those which are soiled, when, as the latter are pulled out, the former are drawn beneath the limb. This bandage is sometimes made by sewing a longitudinal piece to the middle of the several strips; this arrangement, however, is objectionable, as it prevents single strips from being removed when they have become soiled.

Fig. 69.



Bandage of Scultetus.

Handkerchief Bandages.—Handkerchiefs or square pieces of muslin may be resorted to with advantage, in many cases, as provisional, or even as permanent dressings. M. Mayor, a Swiss surgeon, reduced the application of handkerchief dressings to a system, nearly fifty years ago, whence these bandages are generally called "Mayor's handkerchiefs." The various handkerchief bandages are all modifications of the simple handkerchief, or square piece of muslin. The different forms that the handkerchief is made to assume are (1) The *Oblong*, made by simply folding the square once on itself; (2) the *Triangle*, made by bringing together the diagonal angles of a square, the parts of the triangle being the base, the apex or summit, and the angles; (3) the *Cravat*, formed by folding a triangle from its summit towards its base; and (4) the *Cord*, a cravat twisted, the parts of the cravat and the cord being the body and the extremities.

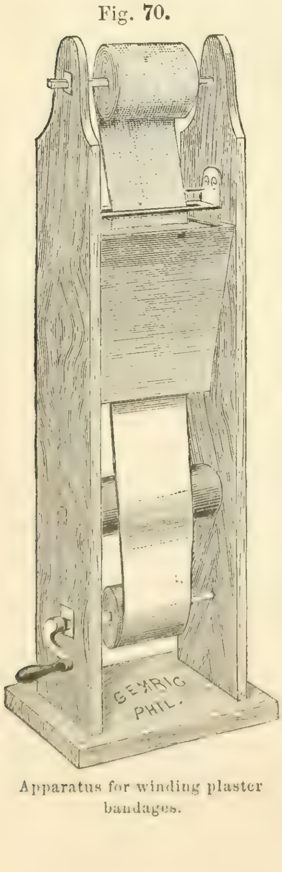
This system of provisional dressings has an elaborate nomenclature founded

upon the shape of the bandages and the anatomical designation of the parts to which they are to be applied. The essential point to be borne in mind in the application of these dressings, is that the base of the triangle, or the body of the cravat, is to be placed on the part, the designation of which forms the first portion of the name of the bandage. The angles or extremities are, as a rule, carried around the part, and either knotted or fastened with pins. The advantage of this arrangement of the names may be illustrated in the case of the Occipito-Frontal Triangle, or the Fronto-Occipito-Labial Cravat. The name of the former indicates that a handkerchief, in the shape of a triangle, is to be used, and that its base is to be applied to the occiput, and its angles carried around the head to the frontal region; that of the latter denotes that a handkerchief folded in cravat form is to be employed, its body being placed on the forehead, and its extremities crossed on the occipital region and terminated on the upper or lower lip, as the case may be.

Fixed Dressings, or Hardening Bandages.—A great variety of substances are used, at the present time, to give greater fixity and solidity to bandages, in the treatment of fractures and other surgical affections. The substances most commonly employed in the preparation of fixed dressings are plaster of Paris, or gypsum, starch, and silicate of potassium; other materials are sometimes used, among which may be mentioned a mixture of chalk and gum, a combination of oxide of zinc and glue, glue alone, and paraffine.

Plaster of Paris Bandage.—The plaster for this purpose should be the extra-calcined variety used by dentists for taking casts for teeth, and by modellers. If it is not fresh and free from moisture, it will fail to serve the purpose for which it is used. This bandage may be applied in two ways:—

Fig. 70.



Apparatus for winding plaster bandages.

First Method. Add dry plaster to some cold water in a basin, and stir the mixture till it becomes of the consistence of cream. Thus prepared, the plaster may be smeared over the surface of a bandage on a limb; or a bandage previously wetted may be loosely rolled in the plaster-cream, and then applied. Strips of bandage dipped in plaster-cream are sometimes applied after the manner of the many-tailed bandage of Scultetus. To render the surface of the dressing smooth after it has been applied in either of the above ways, a little dry plaster may be rubbed over it.

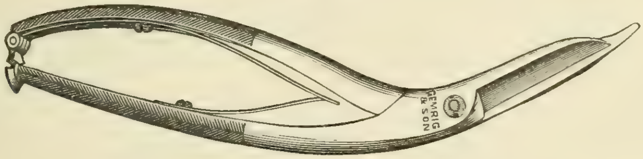
Second Method. The bandages used in this method are made of some loosely-woven material, such as cross-barred muslin, mosquito-netting, or (what is far better than either) crinoline, a substance recommended by Prof. Sayre. This material is cut into strips $6\frac{1}{2}$–$7\frac{4}{5}$ centimetres ($2\frac{1}{2}$–3 inches) wide and $4\frac{1}{2}$–$6\frac{2}{5}$ metres (5–7 yards) long. As these strips are loosely rolled into cylinders, dry plaster is rubbed into their meshes, either by hand or by means of a machine called a plaster bandage winder (Fig. 70). Bandages thus prepared may be kept ready for use in some air-tight receptacle. Before applying one of these bandages, it is placed on end in a basin of tepid water, sufficiently deep to cover it entirely, and is allowed to remain till the bubbles of air cease

to escape through the water from the upper end of the roller; it is then taken out of the water and firmly squeezed between the hands, to remove the excess of liquid, when it is ready for application. When two or more bandages are to be used, a dry bandage should always be put in the water before the saturated one is taken out; if this be done, there will be no unnecessary delay in the application of the dressing. As a roller is applied, the surface of the turns should be gently smoothed by the operator or by an assistant, in order that the plaster may be uniformly spread over the surface of the dressing. Three or four thicknesses of bandage are usually sufficient.

Plaster bandages should never be applied directly upon the skin. The best protective for an extremity is a flannel roller, or a light woollen stocking; for the trunk, a closely fitting knitted shirt or vest. If bandages with dry plaster well rubbed into their meshes are evenly applied to a part after being thoroughly saturated with water, there will be no need of smearing the successive layers, or the outer surface of the dressing, with plaster cream. Under favorable circumstances, a plaster bandage becomes perfectly firm in from fifteen to thirty minutes, and, unlike the other fixed dressings, it expands a little as it hardens. A small quantity of size, or stale beer, put in the water, will retard the setting of plaster; on the other hand, the addition of a little salt will hasten it.

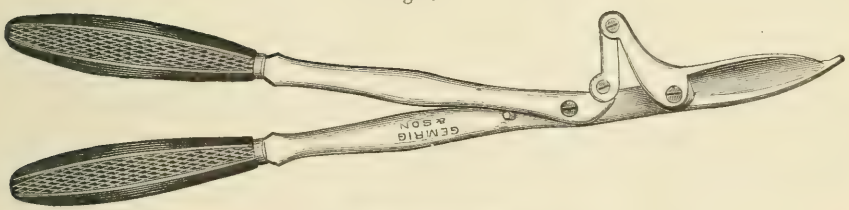
The removal of a plaster bandage, as well as other fixed dressings, may be accomplished by slitting it up with a stout-bladed knife, or with Seutin's or Von Bruns's pliers. (Figs. 71, 72.) The writer has recently had made

Fig. 71.



Seutin's pliers.

Fig. 72.



Von Bruns's pliers.

a plaster-bandage saw, of the shape represented in Fig. 73, which greatly facilitates the division of these bandages. It is necessary that the teeth

Fig. 73.

Saw for removing plaster-of-Paris bandages.

should be widely set, so that a wide groove may be cut in the bandage for the free passage of the saw.

Starched Bandage.—The starch is first mixed with enough cold water to make it of the consistence of cream; then, as the mixture is stirred, boiling water is gradually added to it till it becomes a clear, thickish mucilage, which is known as "clear-starch." The starch mucilage is painted with a brush, or smeared with the hand, over the outer surface of the bandages as they are applied to a limb. To give additional support, pieces of paste-board cut or torn of the requisite size and shape, and thoroughly soaked in starch, are sometimes placed between the layers of bandage. In order that there may be no liability to dangerous constriction of a part, only those bandages that have been washed and well shrunk should be used with starch. The starched bandage dries very slowly, requiring from twenty-four to forty-eight hours before it becomes firm.

Gum and Chalk Bandage.—For this bandage, a mixture of the two substances is made by adding to equal parts of powdered gum arabic and precipitated chalk, enough boiling water to bring the mass to the consistence of cream. This dressing is applied in the same manner as the preceding; it requires only five or six hours to harden, and hence is to be preferred to the starched bandage.

Silicate of Potassium Bandage.—When silicate of potassium (liquid glass) is employed to stiffen bandages, it is painted over the several layers of bandage with a broad brush. It takes about the same length of time to become firm as the starched bandage, and, unless washed bandages are employed, its use is attended with the same dangerous liability to strangulation of the limb. In consequence of the ready solubility of silicate of potassium, the bandage may be easily cut up with scissors after it has been softened by the use of warm water.

Paraffine Bandage.—One disadvantage attributed to the foregoing fixed dressings is their liability to become offensive from the absorption of discharges, especially in cases of compound fracture. Mr. Lawson Tait claims that paraffine, in consequence of its non-absorbent property, is not open to this objection. Paraffine, which melts at from 105° to 120° F., is kept in a liquid state by being placed in a bowl floating in hot water; it may be most conveniently applied by passing through it flannel bandages of loose texture, as they are being placed upon a limb. In the course of five or ten minutes, the bandage will become firm, and, if it be deemed necessary, the dressing may be strengthened by brushing over it melted paraffine. Should the coating of paraffine crack, the damage may be easily repaired with a hot wire.

Glue alone, as used by the late Mr. C. De Morgan, or in combination with *oxide of zinc*, as suggested by Dr. Levis, may be employed to make fixed dressings. It does not possess any decided advantages over the materials already noted, to compensate in any way for the increased trouble which attends its application.

Revulsion and Counter-Irritation.

It has been demonstrated by experience of the most positive character, that artificial irritations, under favorable circumstances, have a decided effect in modifying a great variety of morbid processes. The substances employed to excite external irritation are termed *counter-irritants;* and the

extent of their action varies from the production of superficial redness to the complete destruction of the vitality of the part to which they are applied.

Rubefacients.—These agents, in consequence of their irritating properties, excite, when applied to the surface of the body, intense redness and congestion of the skin, which are of temporary duration only. When it is desirable to make a quick impression on the skin, flannel cloths wrung out of hot water and laid upon the part, will answer the purpose if they are frequently renewed.

Oil of turpentine is not unfrequently used as a counter-irritant, in the form of stupes. These are made either by sprinkling the oil of turpentine over flannel cloths that have been wrung out of hot water, or by dipping these hot cloths into warm turpentine; in either case the excess of turpentine should be squeezed out of the stupes before they are applied. A turpentine stupe ought not to be left on longer than twenty minutes.

A few drops of *chloroform*, on a piece of flannel or folded napkin, confined to the skin by oiled silk, will quickly excite a rubefacient effect.

Mustard-flour is probably more often employed as a rubefacient than any other substance. Of the two varieties of mustard, Sinapis alba and Sinapis nigra, the latter is the more powerful—a fact that ought not to be lost sight of in the use of these substances as revulsives. The advantage attending the use of this material is the ease with which its specific action may be regulated. The usual method of preparing a *sinapism* is to mix the mustard-flour with warm water, and spread the paste on muslin or paper. The surface of the sinapism should be covered with some thin material, such as gauze, to prevent any of the mustard from sticking to the skin when the application is removed. The intensity of the irritating effect of mustard may be diminished by diluting the mustard-flour with wheat-flour, Indian-meal, or linseed-meal; the usual proportions are, for the black variety about one-half, for the white one-third. A sinapism of this strength may be allowed to remain for a period varying from fifteen to thirty minutes, according to the texture of the skin and the sensations of the patient; its action should never be allowed to extend to vesication, for a blister produced by mustard is excessively painful, and slow in healing. After the removal of a mustard poultice, the irritated surface of the skin should be protected by a piece of lint smeared with oxide of zinc ointment or Goulard's cerate. A *mustard foot-bath*, made by putting a tablespoonful or two of mustard-flour into a bucket or foot-tub of water at a temperature of 105° F., is an efficient method of quickly exciting revulsive action. In the employment of counter-irritants with patients who are in a comatose state, or deeply under the influence of a narcotic, care must be observed that the applications are not too long continued, lest troublesome consequences should arise as a result of the impaired vitality of the tissues, or of a temporary loss of the sensation of the patient.

Vesicants.—These substances are employed when it is desirable to make a more decided and permanent counter-irritant effect than that produced by the use of rubefacients. By their specific action on the skin, they cause an effusion of serum, or of serum and lymph, beneath the cuticle, giving rise to vesicles or blisters. When there are indications for rapid vesication, it may be produced by the application of the *aqua ammoniæ fortior*, or of *chloroform* confined to the surface of the body by an inverted watch-glass; or by the employment of iron heated in boiling water. The substance most commonly resorted to for producing vesication, is *cantharis*, or Spanish fly, which may be used in the form of a cerate, or in combination with collodion. There is still another form, the cantharides paper (*charta cantharidis*), which is considered

by some more elegant than either of the above preparations, and nearly as efficient. The most convenient way of using the *ceratum cantharidis* is to spread it on a piece of adhesive or diachylon plaster, leaving a margin of about $1\frac{1}{2}$–2 centimetres ($\frac{1}{2}$ to $\frac{3}{4}$ of an inch) wide, uncovered, which will adhere to the skin and thus hold the blister in position. The average length of time that a fly-blister may be allowed to remain in contact with the skin, is from six to eight hours; then it should be removed, and the part covered with a flaxseed-meal poultice. A blister raised in this way is not very painful, nor is it apt to be followed by strangury. In cases in which the skin is delicate, or in which urinary irritation is apprehended, camphor, alone or in combination with opium, may be incorporated with the cerate before it is applied. *Cantharidal collodion*, painted on the skin in three or four layers, with a camel's-hair brush, is the best means of blistering in cases of maniacs or other patients whose movements are not easily controlled; it is, likewise, a very convenient application for uneven or irregular surfaces. Blisters must be cautiously used with children, even with those who are robust, and they are positively contra-indicated in the case of children suffering from any low form of disease.

When a blistered surface is to be healed as quickly as possible, the vesicle should be carefully punctured at the most dependent point, to let the serum escape, and, without detaching the cuticle, the part should be covered with oxide of zinc ointment or simple cerate. If, on the other hand, there is need for keeping up the derivative effect of a blister, the cuticle should be stripped off and the denuded surface dressed with savine cerate or mezereon ointment, or the compound resin cerate.

Nitrate of silver is sometimes applied to the skin for the purpose of exciting counter-irritation. A strong solution of this salt may be used where the object is simply to produce rubefaction; but, for the purpose of exciting vesication, preference should be given to the solid stick. Freely applied to the scrotum in this form, nitrate of silver is thought by some surgeons to be efficacious in abating an acute epididymitis.

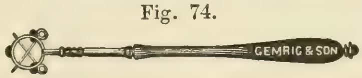
Acupuncture.—This method of exciting counter-irritation is effected by thrusting needles deeply into the subcutaneous tissues, where they are allowed to remain for a variable length of time. The needles should be of steel, polished, strong, sharp pointed, and from 5 to 10 centimetres (2 to 4 inches) long, and should have round metallic heads, or be fixed in cylindrical handles. In introducing the needles, the skin should be made tense between the thumb and fingers of the left hand, while each needle is forced through the integument into the deep-seated structures by a rotatory motion. As it is withdrawn, the skin around each needle ought to be supported. In performing the operation of acupuncture, certain localities containing important organs, such as large bloodvessels, the viscera, joints, etc., must be avoided. Acupunctuation has been found of service in cases of deep-seated neuralgia, especially of the sciatic nerve, cases of muscular rigidity, obstinate rheumatic affections, etc.

Issues are ulcers made artificially by the application of caustics, or the moxa, or by the use of the knife, for the purpose of relieving either local or general disease by establishing a permanent, derivative action. When they are established with a view of producing a drain on the system, certain situations, such as the nape of the neck, the insertion of the deltoid muscle on the outer side of the arm, and the outer aspect of the thigh, should be selected; for in these localities the subcutaneous areolar tissue is abundant, and there are no important bloodvessels or nerves. In the case of local affections, circumstances will determine the points at which issues are to be made. Salient points of the skeleton and the immediate vicinity of large bloodvessels and

nerves should, however, always be avoided. The plan usually practised in making an issue, is to protect the surrounding skin by covering it with a piece of adhesive or diachylon plaster, in which a hole is cut a little smaller than the proposed eschar. A ring of wax may be used instead of plaster. A small piece of caustic potassa, or Vienna caustic made into a paste by mixing it with a little alcohol, is placed in the hole, and kept in position by another strip of plaster. In an hour or two, the strips of plaster should be removed, and the part washed with vinegar and water, to check the further action of the caustic; a poultice of flaxseed-meal should then be applied, to hasten the separation of the slough. The ulcer remaining after the removal of the eschar may be kept from healing by placing in it an *issue-pea* or a *glass bead*, which may be maintained in position by means of a small compress of lint and a strip of plaster; or, if the issue be on the arm, by a wire-gauze armlet.

The moxa is occasionally used to make an issue, but its application is so painful that a local anæsthetic should then always be employed. The moxa is composed of some combustible material, such as cotton, lint, agaric, the pith of the sunflower, etc., rolled into cylindrical or pyramidal shape, and is designed to be burnt in contact with the skin, for the purpose of producing an eschar. That the combustion of the moxa may be more rapid, and the pain attending its application less prolonged, it is customary to make it of cotton or lint impregnated with nitrate or chlorate of potassium. To facilitate the application of the moxa, a convenient instrument called the *porte-moxa*, or "moxa-bearer," may be employed. (Fig. 74.) The eschar left in the skin

Fig. 74.



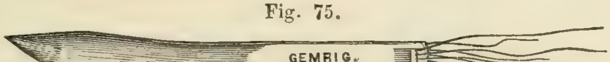
Porte-moxa.

after the burning of the moxa, is somewhat greater in extent than the base of the latter. The treatment of the slough and of the ulcer is the same as that described in the preceding paragraph.

The knife may be resorted to for establishing an issue, either by raising the integuments and cutting them from within outwards, or by making a crucial incision, well down into the subcutaneous areolar tissue. Issues made in this way are always troublesome to keep open, and hence this method is not often practised.

The Seton, which is simply a subcutaneous issue, or a sinus with two openings, is established by introducing a narrow strip of muslin, a small roll of thread, a piece of lamp-wick, or a strip of India-rubber cloth, through the base of a fold of the integument. This may be accomplished either by using a *seton-needle* (Fig. 75), or by means of a sharp-pointed bistoury and an eyed

Fig. 75.



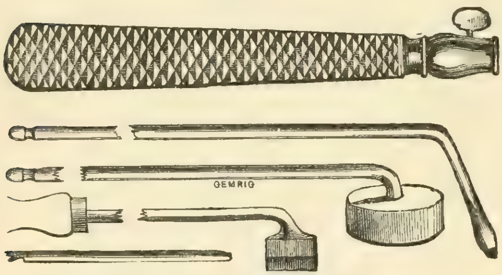
Seton-needle.

probe. A seton should pass deeply into the superficial fascia, for if it be carried between the skin and fascia, the former will slough and leave an open wound; in order to get free drainage, one opening should be a little lower than the other. When the seton-thread is in position, its ends are to be loosely knotted, and it should not be disturbed till suppuration is fully established in the wound. After this, the wound is to be dressed every day,

and the seton-thread, either oiled or smeared with some stimulating ointment, if it be desirable to increase the quantity of the discharge, should be moved a little at each change of dressing. Setons are occasionally used to empty chronic abscesses or cysts; in cases of the latter, and in those of hydrocele, the presence of a seton in the sac will sometimes effect a cure by exciting sufficient inflammatory action to cause adhesion of the walls.

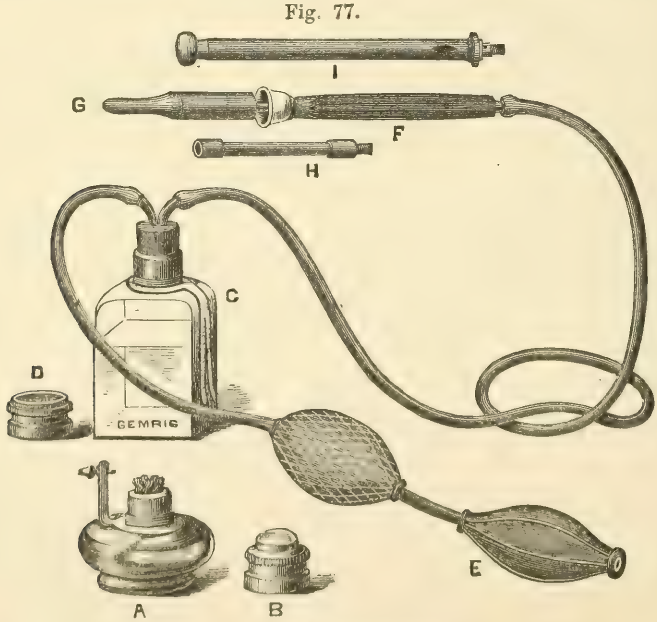
The Actual Cautery, consisting of some form of metallic substance brought to a high degree of temperature, constitutes the most powerful counter-irritant in use. It is likewise employed for the purposes of checking hemorrhage and destroying diseased growths. The cauteries most commonly employed are made of iron, and are fixed in handles of wood or other non-conducting material, and have their heads or extremities fashioned in a variety of shapes, as the olive, the button, the hatchet, etc. (Fig. 76.) This variety in shape is designed to meet the special indications for which cauting-irons are used, and to suit different localities. In an emergency, an ordinary knitting-needle, or a poker, or other piece of iron, may be made to serve the purpose. The irons may be heated in a brazier which usually accompanies a set of the instruments, or in an ordinary fire, or by the flame of a spirit-lamp. When the actual cautery is resorted to for its revulsive effect, the hatchet-shaped iron is the one usually selected. This, heated to a dull red heat, should be quickly drawn over the skin in

Fig. 76.



Cauting-irons of various shapes.

Fig. 77.



Paquelin's thermo-cautery.

A, spirit lamp; B, cover for lamp; C, bottle containing benzole; D, cover for bottle; E, India-rubber bulbs and tubing; F, handle for knives; G, H, platinum knives; I, platinum button.

lines about $2\frac{1}{2}$ centimetres (one inch) apart, either parallel to or crossing one another. The intense burning that follows the application of the hot iron may be allayed by placing on the cauterized part compresses wrung out of cold water, or saturated with equal parts of olive oil and lime-water. It is not deemed prudent to apply the actual cautery to the skin covering salient points of the skeleton, or immediately overlying important organs. Bruce's gas cautery, which consists of a point, disk, or wedge of platinum heated by a flame of gas, has the advantage over the ordinary cauting-iron, that it can be easily maintained at a high temperature while it is in contact with moist tissue.

A very convenient and efficient form of *thermo-cautery* has been recently introduced by Paquelin, which comprises two hollow knives (Fig. 77, G, H) and a hollow button of platinum (I); a metallic handle (F), likewise hollow and covered with wood; a reservoir for benzole (C); and rubber bulbs and tubing (E), similar to those used with the hand spray-apparatus. In preparing the cautery for use, the platinum extremity, in which there is platinum sponge, is first heated by the flame of an alcohol lamp (A); it is then quickly made incandescent by passing through it a continuous stream of air saturated with the vapor of benzole. By compressing the rubber bulb, air is forced into the rubber bag surrounded with netting, and the elasticity of this causes a steady flow of air through the reservoir or bottle containing benzole; the air thus charged is conveyed by the rubber tubing to the platinum point.

The use of the *galvanic cautery* will be referred to on a subsequent page.

Bloodletting.

The operation of bloodletting is occasionally resorted to, both as a local and as a general remedial measure. The methods by which local depletion (that is, from the capillaries) is effected, are scarification, puncturation, cupping, and leeching. General bloodletting comprises venesection and arteriotomy.

Scarification consists in making small incisions with a lancet or a sharp-pointed bistoury in the surface of a congested or inflamed part. By means of these incisions, the overloaded capillaries are promptly relieved, and a vent is afforded for the escape of transudation. The cases in which this operation is most efficacious are, inflammation of the integuments, engorgements of the tongue and tonsils, chemosis of the conjunctiva, and urinary infiltration. The incisions should be in parallel rows, and, as a rule, should correspond in direction to the long axis of the part. Their length and depth, as well as their number, must be determined by the circumstances of each individual case. Care must be taken that the large subcutaneous veins are not wounded. Warm fomentations will increase and prolong the flow of blood from the small wounds.

Puncturation is an operation somewhat similar in character to that just described, and may be done with a sharp-pointed, narrow-bladed bistoury. It is of marked service in cases of acute epididymitis, phlegmonous erysipelas, etc., both by relieving tension and by effecting depletion.

Cupping.—Under this head are included two minor operations, viz., dry-cupping and wet or bloody-cupping. The use of cups relieves deep-seated inflammation by inviting the blood to the surface.

Dry-cupping is indicated in cases of inflammation in which the action of a derivative is desired without the abstraction of blood. In an emergency, this

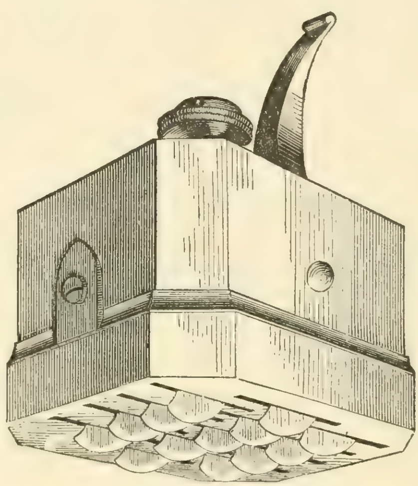
may be accomplished by means of wineglasses or small tumblers instead of cupping-glasses. When the former are used, the air in them may be quickly rarefied by burning in them small rolls of paper, or little masses of cotton wet with alcohol, or by the introduction of the flame of a spirit lamp for a moment or two. In using cupping-glasses, either for dry or wet-cupping, the glasses are first placed on the part, and then the air in them is exhausted by means of a portable air-pump (Fig. 78); the immediate effect of the removal of the air is marked congestion of the integument covered by the glasses. Cupping-glasses are easily removed by opening the stopcock with which they are provided; or they may be tilted to one side, and the skin gently pressed away from the edge of the glass on the opposite side. They should never be pulled off.

Wet or bloody-cupping.—By this means local depletion is easily effected, and the quantity of blood abstracted may be accurately determined. The instruments required for this operation are a scarificator (Fig. 79), cupping-glasses, and a portable air-pump, or a vulcanized India-rubber bulb (Fig. 80);

Fig. 78.

Cupping-glass and portable air-pump.

Fig. 79.



Scarificator for wet-cupping.

Fig. 80.

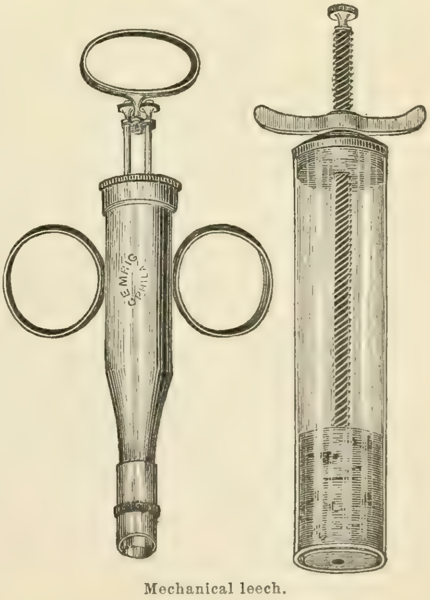
Cupping-glass with India-rubber bulb.

in place of the scarificator, any sharp-pointed knife may be used. As a preliminary to the performance of this operation, the skin should be sponged with warm water, and if necessary shaved. The cups are placed on the surface, to produce superficial congestion, and in the course of a minute or two should be removed, and the scarificator immediately applied. As soon as the incisions are made by springing the set of lancets concealed in the scarificator, the cups should be promptly replaced. When the cups become filled with blood, as their suction power is exhausted, they should be taken off and emptied; and, if more blood is to be abstracted, they may be reapplied to the same spots, or fresh cups may be substituted. After they are removed, the part should be carefully washed, and dressed with compresses and strips of plaster or a bandage. In using the scarificator, the blades should be set so as to cut through the true skin only. If a knife be used to make the scarifications, the same care must be exercised not to encroach upon the subcutaneous areolar tissue; the incisions should be parallel, and about one centimetre (one-third of an inch) apart. Cupping glasses should not be applied in the immediate vicinity of inflamed tissues, nor over the mammary region. Wet-cupping is

always followed by scarring, hence wet-cups should never be put on the upper part of the chest or shoulders of women.

Leeching is not often done by the surgeon himself; still its importance as a remedial measure renders a knowledge of its practical application of service to every practitioner. It is a convenient method of taking blood from certain localities where it is impossible to employ cups. In this country, two varieties of leech are used, known respectively as the American, and as the European or Swedish leech; the former variety is estimated to draw about four grammes (one fluidrachm) of blood; the latter nearly four times as much. The quantity of blood abstracted may be increased by applying warm fomentations to the leech-bites. In selecting leeches, preference should be given to those which are active and healthy; they should be taken from water an hour before they are applied, and should be dried in a soft, dry cloth. The part to be leeched must be clean and free from hair. If the leeches are slow in taking hold, their action may be hastened by smearing a little milk or blood on the skin; immersion of the leeches in lukewarm water or small beer is said to stimulate them to bite more actively. When two or three leeches only are to be applied, they may be taken between the thumb and fingers and held with their buccal extremity to the part. If a larger number be used, they may be conveniently confined to the surface by covering them with an inverted tumbler, or a loose mass of cotton. By means of a leech-glass or a small cone of stiff paper, a leech may be kept in contact with a particular part, as the inner canthus of the eye, the gum, the verge of the anus, etc., till it adheres; for the cervix uteri a speculum should be used. In cases of inflammation, leeches should be applied to the parts surrounding the seat of disease, and not directly over it; nor should they be put on the eyelids or the scrotum, for here, in consequence of the large amount of loose cellular tissue and the delicate nature of the skin, unsightly ecchymoses are almost sure to follow. Leeches should not be forcibly removed; when they show no disposition to relax their hold, a little salt or snuff sprinkled on their bodies will cause them to let go and drop off. Injections of tobacco smoke or solutions of common salt will facilitate the detachment and removal of leeches from the inside of the mucous outlets. Usually there is no difficulty in checking hemorrhage from a leech-bite; exposure to the air, or the application of dry lint, is generally sufficient. Should the bleeding continue obstinately, it may be stopped by the application of dossils of lint wet with Monsel's solution (liquor ferri subsulphatis), or a warm, saturated solution of alum; or by touching the wound with a pencil of nitrate of silver, or the actual cautery improvised by heating the end of a darning needle to a dull-red heat. If all these means fail, the bleeding surface must be constricted by passing a threaded needle below it and winding the thread around beneath the ends of the needle.

Fig. 81.



Mechanical leech.

The artificial or mechanical leech is a cupping apparatus which combines in a single instrument a scarificator, a cup, and an exhausting syringe; or consists of two parts, viz., a small steel cylinder containing a lancet that is propelled by a cord, or, better, projected by a spring, and a hollow glass cylinder with a piston that is moved by a screw (Fig. 81). In using this apparatus, the piston of the exhausting instrument should be drawn out slowly, or at the same rate as the blood flows from the wound. If a vacuum be made over the wound before sufficient blood has escaped to fill the cylinder, its edge will be apt to compress the integuments to such a degree as entirely to check the flow of blood.

Venesection.—For this operation, any superficial vein which is accessible, and which can be readily made prominent, may be selected; hence the veins at the bend of the elbow, those in the vicinity of the inner ankle, and the external jugular vein, are generally chosen. In this country, the operation is usually performed either upon the *median basilic* or the *median cephalic vein*. The median basilic vein is generally larger in size, more superficial in situation, and less movable than the median cephalic, and therefore preference is usually given to the former; although an operation upon the latter, in consequence of its remoter position from the course of the brachial artery, is attended with less risk. At the bend of the elbow, the median basilic vein crosses the brachial artery to the inner side of the tendon of the biceps muscle, and is separated from the artery by the dense bicipital fascia. With a little care on the part of the operator, the danger of puncturing the artery may be avoided by opening the vein either above or below the point at which it crosses the other vessel.

There are required for the operation of venesection, a lancet or sharp-pointed bistoury; a piece of bandage or tape, from two to four centimetres (an inch or an inch and a half) wide; a small compress; a bowl; a staff; a basin of water, sponge, and towel. The patient should be in the sitting posture, grasping a staff or other firm body in his hand, with his arm bared and extended, and his forearm supinated. The bandage or tape should be applied to the arm a few centimetres (an inch or two) above the elbow, sufficiently tight to arrest the superficial venous circulation without checking the radial pulse. Now, as an assistant holds the bowl in a convenient position for catching the blood, the operator grasps the upper part of the forearm with his left hand in such a way as to enable him to support the limb, and, at the same time, to control the vein with his thumb just below where the puncture is to be made; then, with a lancet held firmly between the thumb and forefinger of his right hand, he quickly incises the distended vessel at a point not directly over the artery. The incision should be about 5 millimetres (a fifth of an inch) long, and in a direction oblique to the long axis of the vein.

On removing the thumb from the vein below the incision, the blood will flow in a continuous stream if the vein be fairly opened, and if there be no obstruction in the wound. Should the escape of blood be slow, the patient should be directed to grasp firmly the staff or other body that he holds in his hand; or the operator may stroke the forearm from the wrist towards the elbow. If the position of the forearm be changed from supination to pronation, after the vein has been incised, the wound of the skin will not correspond with that of the vein, when there may either be an arrest of the flow of blood, or the blood may escape into the cellular tissue and give rise to a thrombus. As soon as the required quantity of blood has been drawn, the operator places the index finger or thumb of his left hand on the wound, and quickly loosens the fillet or bandage above the elbow. The compress is now placed on the wound and secured by a figure-of-eight bandage, the intersec-

tions of which should be made directly over the compress; a few circular turns may be carried around the elbow to give additional security. It is advisable, also, to apply a firm roller to the hand and forearm, to support the venous circulation of these parts till the wound is healed. The arm should be carried in a sling for a few days.

Venesection may be practised on the *external jugular vein*, whenever, either from excess of fat, or in cases of children, the veins at the bend of the elbow are not easily found. To distend this vessel, and, at the same time, to prevent the admission of air when the incision is made, the thumb of the operator, or a pad, should be placed over the vein at the outer edge of the sterno-cleido-mastoid muscle, just above the clavicle. If the pad be used, it may be secured by a bandage carried over the pad and through the opposite axilla. The best place to incise the vein is over the sterno-cleido-mastoid muscle; the opening should be parallel with the fibres of the muscle. By making the incision in this direction, the fibres of the platysma myoides muscle (which is superficial to the vein) will be divided transversely, and, by their retraction, the oblique opening in the vein will be kept patulous. In order that all risks of air gaining access to the vein may be avoided, the wound must be securely closed before the pad is removed from the vein in the supra-clavicular fossa.

When this operation is performed in the veins of the ankle the *internal saphena* is selected. That this vessel and its tributaries may be fully distended, the foot and ankle should be immersed in warm water for a few minutes before the constricting band is placed around the lower third of the leg. The internal saphena vein, where it passes up in front of the internal malleolus, should be opened by an oblique incision, made from behind, forwards and upwards. The accompanying nerve lies immediately behind the vein.

ARTERIOTOMY.—The vessel usually selected for this operation is the temporal artery, above the zygoma, or one of its two principal branches, either of which may be easily found. Whichever trunk be chosen, it must be firmly held in position by the finger or thumb of the operator, placed on it below the point at which the incision is to be made. A transverse opening should be made in the vessel with a sharp-pointed bistoury or lancet, and, if the blood does not flow with sufficient freedom, the vessel may be cut entirely across. The hemorrhage may be checked by a firm compress laid on the wound and secured by a circular bandage of the vault of the cranium; if this fail to arrest the bleeding, both ends of the vessel may be ligatured in the wound, and the same dressing applied.

TRANSFUSION OF BLOOD.

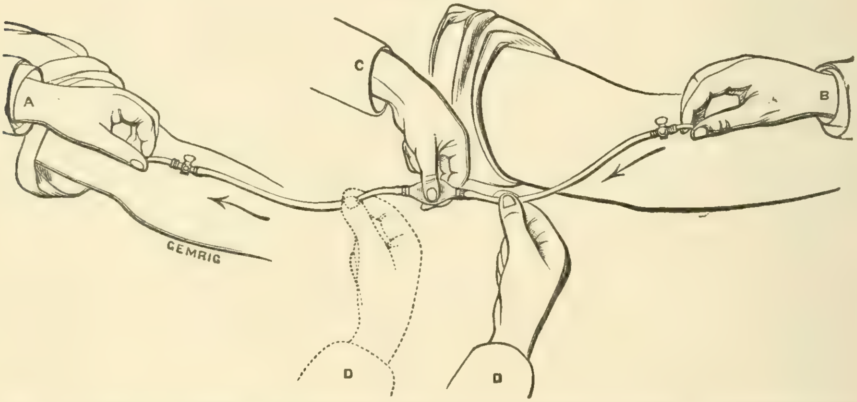
This operation has never found much favor with the profession in this country, partly owing to the fact that a very large proportion of the patients operated upon die (though not in consequence of the operation, but rather in spite of it), and partly as a result of the many difficulties attending the performance of the operation itself. There are two methods by which transfusion may be effected: the *immediate or direct*, and the *mediate or indirect*. By the former, blood is conveyed directly and without exposure to the air, from the vessels of one person to those of another; by the latter, it is first drawn and then injected either as a whole or after being deprived of its fibrine. It would seem, theoretically at least, that the immediate method possessed the greater advantages, by virtue of the fact that by it blood is transferred from one individual to another in its natural state, and is not contaminated by

being exposed to the surrounding media. Panum, of Copenhagen, and other observers, have, however, demonstrated by experiment that blood exposed to the air for a brief period, and deprived of fibrine, is not thereby rendered unfit for introduction into the bloodvessels.

Direct Transfusion.—The means most commonly employed in *direct transfusion* are the Aveling syringe and Roussel's apparatus. The *Aveling syringe* is simply an India-rubber tube, about 50 centimetres (19½ inches) long, with a small bulb in the centre, and having metallic extremities provided with stopcocks; for connecting the tube with the bloodvessels, there are two bevel-pointed metallic canulæ. A small, sharp-pointed bistoury and a delicate pair of forceps are used for exposing and opening the vein.

In using the Aveling syringe, it is filled with tepid water, or a weak saline solution, for the purpose of displacing the air; this is done by placing the rubber tube, the stopcocks being open, in a shallow basin containing the liquid. The person supplying the blood, sometimes called the blood-donor, is brought to the bedside of the patient and directed to place the arm from which the blood is to be drawn, nearly parallel with the patient's arm. The operator now proceeds to open the most prominent vein in the bend of the patient's elbow, and to insert into it one of the canulæ filled with water, with the point directed towards the body, while an expert assistant, at the same time, introduces the other canula, also filled with water, into the donor's vein; in the latter the point of the canula should be directed towards the

Fig. 82.



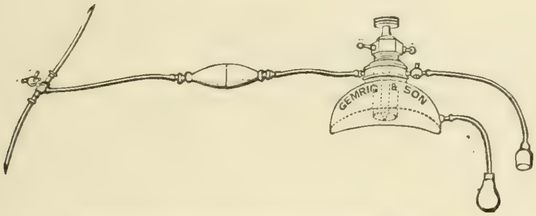
Aveling's transfusion apparatus. A B, assistant's hands holding the canulæ in position; C D, operator's hands, compressing the bulb and, alternately, the afferent and efferent tubes.

hand. As the canulæ are held steadily in position by assistants, they are quickly connected by the tube, the stopcocks of which are closed before it is taken out of the basin, to prevent the escape of the water which displaced the air. Now on opening the stopcocks, a direct vascular communication is established between the patient and the donor. (Fig. 82.) The introduction of the contents of the bulb into the patient's vein is effected by the operator slowly compressing the bulb with one hand, while he keeps the tube closed on the donor's side with the finger and the thumb of the other hand. Then by releasing the tube on the donor's side of the bulb, and closing it on the patient's side, blood will flow from the donor's vein into the bulb as it is slowly permitted to expand. Communication on the donor's side is again closed, and opened on the patient's side, when, as the bulb is compressed a second time, its contents are driven into the patient's vein. By this alternate

emptying and filling of the bulb, direct transfusion is effected. By bearing in mind the fact that 8 grammes (2 drachms) of blood are emptied by each compression of the bulb, the quantity transferred may be readily determined. After the operation is completed, the wounds of the veins are treated as in a case of venesection.

The *apparatus devised by Roussel*, for effecting direct transfusion, is much more complicated than the Aveling instrument, and hence its successful employment necessitates considerable familiarity with its use on the part of the operator. The apparatus (Fig. 83) consists of a glass receiver containing a

Fig. 83.



Roussel's apparatus for transfusion of blood.

lancet, and a Higginson's pump, which connects the receiver with a canula that is to be inserted into the patient's vein. The receiver is placed on the blood-donor's arm, directly over the vein from which the blood is to be obtained, and is retained there by atmospheric exhaustion. In order to get rid of air, the apparatus is first filled with a solution of bicarbonate of sodium in the proportion of 2 grammes ($\frac{1}{2}$ drachm) of the salt to 1 litre (a quart) of water; then the donor's vein is punctured by means of the lancet in the receiver, and, as soon as the sodium-solution is displaced by the blood, the latter is slowly pumped into the recipient's vein.

Indirect Transfusion.—The *mediate* or *indirect method* of transfusing blood has been very often resorted to in this country. In an emergency, this operation may be done with few instruments. The first time that the writer had occasion to perform transfusion, the instruments used were a hard rubber syringe, to which was fitted a tubular needle (sometimes used by gynæcologists in operations on the female perineum), two porcelain bowls, a linen strainer, a brush made of fresh broom-corn, and a sharp-pointed bistoury. By means of these instruments, five ounces of defibrinated blood were successfully injected into the veins of a woman who was moribund from excessive hemorrhage consequent upon an abortion. The patient made a quick recovery.

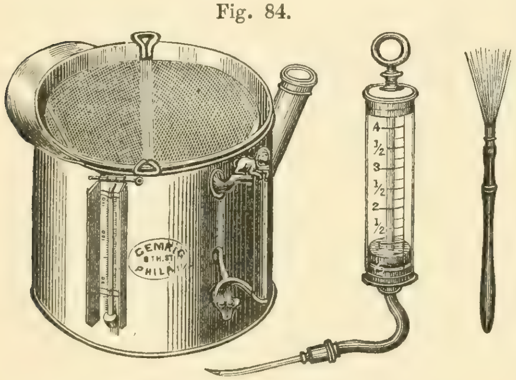
Various plans and many ingenious apparatuses have been devised with a view to facilitating the safe performance of this operation; but with care it may be done as safely and as expeditiously with the simple instruments just named as with the most elaborate apparatus.

Hewitt's Apparatus.—Dr. Graily Hewitt has devised an apparatus by which blood, before it has had time to coagulate, may be introduced into an individual's vein. It comprises a glass syringe holding 64 grammes (2 ounces), with a piston, easily removed and inserted, and a curved nozzle provided with a stopper. There is also a curved stylet and canula (the latter fitting the nozzle of the syringe), for insertion into the recipient's vein. In using this instrument, the blood is allowed to flow into the syringe, the piston having been previously removed, and the nozzle closed with the stopper. During this part of the operation, the surgeon or a dextrous assistant should open the recipient's vein, and insert the canula closed with the stylet. As

soon as the syringe is full, the piston is attached, and the nozzle is inserted into the canula, the stopper and the stylet having been taken out. The blood, now, is slowly injected by forcing home the piston. In order that more blood may be easily abstracted for another injection, the supplier should be directed to keep the opening in his vein closed with his thumb or finger till the syringe is cleansed and prepared for receiving another supply. The success of this operation depends upon the expedition with which it is performed. Not more than two minutes should be permitted to intervene between the reception of the blood in the syringe and its introduction into the recipient's vein; otherwise, coagulation of the blood is liable to take place, which would seriously embarrass the future steps of the operation.

Allen's Apparatus.—Mediate transfusion is commonly effected in this city (Philadelphia) by means of an apparatus that was first suggested by Dr. J. G. Allen, and subsequently modified by Dr. T. G. Morton and the writer. The apparatus consists of a blood-can; a strainer, either metallic or linen; a graduated glass syringe holding five or six ounces; a curved canula with its point bevelled on the convex side; a brush, either made of fine wire or of fresh broom-corn, and a lancet or sharp-pointed bistoury. The blood-can has two compartments, an outer for hot water, and an inner, conical in shape, and extending down into the former, for the reception of the blood as it flows from the supplier's vein. To the side of the can is affixed a clinical thermometer, the curved bulb of which projects into the hot-water chamber; there is likewise a short tube communicating with this chamber for the introduction of hot water. The conical wire strainer is made to fit accurately the conical blood-chamber. A short piece of flexible tubing is used to connect the nozzle of the syringe with the canula. (Fig. 84.)

Fig. 84.



Allen's transfusion apparatus, modified.

In the employment of this apparatus, the first step is to fill the outer chamber of the blood-can with water at a temperature of 110° F.; should the temperature fall below 100° F. during the performance of the operation, more hot water at the former temperature should be added. The syringe should be kept in hot water till it is required. The supplier's vein should now be opened, as in venesection, and, as the blood escapes, the blood-can with the conical strainer should be held in a convenient position for receiving it. Before the blood in the can begins to coagulate, it should be slowly stirred with the wire brush to separate the fibrine; and from time to time the brush should be cleansed in warm water to keep it free from coagula. If desirable, the abstraction of the blood and its preparation for injection may be attended to by an assistant in an adjoining room, while the surgeon himself lays bare the recipient's vein and inserts the point of the canula. If a sharp-pointed canula be used, its point may be thrust through the thin wall of the vein into its cavity; but if the canula be blunt, it is a safer plan to place a ligature around the vessel on the distal side, and make an opening in it for the introduction of the canula.

As soon as the fibrine of the blood in the can is separated, the strainer is removed, and with it all fragments of clot and foreign matter, leaving nothing but defibrinated blood in the can, surrounded with hot water. The syringe

with the flexible tube attached is then filled with defibrinated blood, and quickly connected with the canula which has previously been introduced into the recipient's vein. The blood should be slowly and steadily injected. If air be drawn into the syringe with the blood, it may be expelled before the syringe is attached to the canula by holding the syringe in a vertical position with the nozzle upwards, and pushing in the piston sufficiently far to displace the air. Should it be deemed necessary to introduce more than one syringe-ful, the syringe may be charged again with defibrinated blood, and the injection repeated. The wounds of the veins of the supplier and the recipient should be treated as in a case of ordinary venesection.

Many other ingenious instruments have been devised for effecting mediate transfusion, among which may be mentioned Collin's apparatus, which is used in the French army, and Hasse's syringe. In Hasse's syringe, the piston is moved by a female screw, which enables the operator to regulate the flow of blood with the utmost nicety. Transfusion by hydrostatic pressure is urgently recommended by Dr. Friedrich Esmarch, who considers it free from many of the objections which have been urged against the use of the syringe.

Arterial Transfusion, as recommended by Hüter, is occasionally practised. In this operation, defibrinated venous blood is injected into an artery (usually the radial above the wrist, or the posterior tibial behind the inner malleolus), towards the distal extremity of the limb. The artery is exposed and secured by a ligature; it is then opened on the distal side of the ligature by a valvular wound, into which the point of a canula or the nozzle of a syringe is introduced. When the operation is completed, the artery is cut across and the peripheral end ligatured.

Auto-transfusion is a term applied to an expedient that may be resorted to in cases of excessive hemorrhage to support a moribund patient till transfusion can be performed, or other means of resuscitation adopted. It consists in the application of elastic bandages, or, if these be not at hand, muslin bandages, to the extremities, for the purpose of forcing the blood towards the vascular and nervous centres.

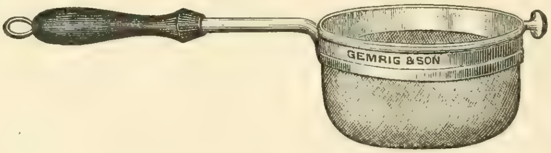
Intra-venous Injections of Milk, or of various Saline Solutions, are sometimes employed, as a substitute for transfusion, after excessive hemorrhage, and in diseases which greatly deteriorate the quality of the blood, as pernicious anæmia, epidemic cholera, carbonic acid poisoning, etc. In 1850, Dr. E. M. Hodder, of Toronto, first made use of milk injections in the treatment of cholera collapse. Since then, this operation has been repeated by Dr. J. W. Howe, Dr. T. Gaillard Thomas, Dr. Bullard, and others, in the treatment of various disorders, with more or less benefit to the patients. The writer has himself resorted to infusion of milk

Fig. 85.

Funnel and tube for intra-venous injection of milk.

eleven times, with sufficient success to encourage him in the belief that, under certain circumstances, the procedure is perfectly justifiable, and that milk introduced into the system in this way may become a valuable therapeutic resource. Intra-venous injection is an easier operation than transfusion, and is most conveniently effected by hydrostatic pressure. The apparatus used by the writer consists of a glass funnel holding about 160 grammes (5 ounces), connected with an India-rubber tube to which is attached a small curved canula provided with a stopcock. (Fig. 85.) A cup-shaped strainer of fine wire, made to fit the expanded extremity of the funnel, is an important part of the apparatus. (Fig. 86.)

Fig. 86.



Strainer for intra-venous injection of milk.

Either cow's or goat's milk may be used, and, as it is absolutely essential that the milk be perfectly fresh, and alkaline or neutral in reaction, it should be taken from the animal immediately before it is injected. The surgeon exposes a prominent vein in the bend of the patient's elbow, and raises it up by passing a probe or director beneath it, while an assistant fills the apparatus by pouring the milk into the funnel through the wire strainer. In order that no air may be left in the apparatus, the canula with the stopcock open is held vertically alongside of the funnel, and, as the milk begins to flow from the canula, the stopcock is closed; by this plan the milk is retained in the canula by atmospheric pressure. The sharp point of the canula is now thrust into the lumen of the vein (or, if the vein be small or collapsed, a V-shaped incision may be made in it for the canula), when, on opening the stopcock and raising the funnel above the level of the patient's arm, the milk will flow into the vessel. The rate at which the milk enters the vein may be regulated by the stopcock, or by varying the height at which the funnel is held above the arm.

Artificial Respiration.

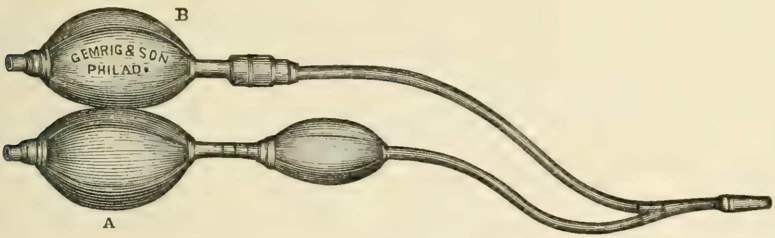
Artificial respiration is resorted to in cases of threatened death from apnœa consequent upon drowning, inhalation of irrespirable gases, profound anæsthetization, or other causes that act by temporarily checking or interfering with the function of breathing. Two conditions are essentially necessary to the successful application of this procedure: these are (1) an unobstructed passage for the entrance of air to the lungs, and (2) the absence of all obstacles to free expansion of the chest-walls. Hence mucus, free liquids, or foreign bodies in the air-passages must be removed—if necessary, by tracheotomy; and all bands or tight clothing around the chest and neck must be loosened.

Mouth to Mouth Inflation is a method of practising artificial respiration sometimes adopted in cases of great urgency, as a temporary expedient till other more efficient measures may be instituted. It is especially applicable to cases of children under six months of age, in consequence of the weak and inelastic condition of their chest-walls. Instead of the operator applying his

mouth to that of the patient, air may be introduced into the lungs through a flexible catheter passed into the trachea.

The Bellows may be employed as a means of forcing air into the lungs. Dr. Richardson, of London, has devised a "pocket-bellows" (Fig. 87) which

Fig. 87.



Richardson's bellows for artificial respiration. A, bulb for filling the lungs; B, bulb for exhausting them.

consists of two elastic bulbs terminating in a single tube. This tube is inserted into the nostril, and, the other nostril and the mouth being closed, air may be driven into the lungs by compressing one of the bulbs (A), and withdrawn by compressing the other (B). This is an ingenious imitation of natural respiration. The entrance of air into the œsophagus, when either of the two methods just described is practised, may be prevented by pressing the larynx upwards and backwards.

Howard's Direct Method of Artificial Respiration.—The three methods by which artificial respiration may be most effectively practised are Dr. Benjamin Howard's "Direct Method," Sylvester's Method, and Marshall Hall's "Ready Method." In this country, the "*direct method*" is generally acknowledged to be the best. It has been adopted by the United States Government Life Saving Service, the Life Saving Society of New York, etc. Dr. Howard gives the following rules for the direct method:—

Rule I.—"To drain off Water from Chest and Stomach. *Instantly* strip the patient to the waist. Place him face downwards, the pit of the stomach being raised above the level of the mouth by a large, hard roll of clothing placed beneath it. Throw your weight forcibly two or three times, for a moment or two, upon the patient's back, over roll of clothing, so as to press all fluids in the stomach out of the mouth."

The above rule is to be followed only in case of drowning; in apnœa from other causes it is to be omitted.

Rule II.—"To perform Artificial Breathing. *Quickly* turn the patient upon his back, the roll of clothing being so placed beneath as to make the breast-bone the highest point of the body. Kneel beside or astride patient's hips. Grasp front part of the chest on either side of the pit of the stomach, resting your fingers along the spaces between the short ribs. Brace your elbows against your sides, and, steadily grasping and pressing forwards and upwards, throw your whole weight upon chest, gradually increasing the pressure while you can count one—two—three. Then *suddenly* let go with a final push, which springs you back to your first position. Rest erect upon your knee while you can count one—two; then make pressure again as before, repeating the entire motions at first about four or five times a minute, gradually increasing to about ten or twelve times. Use the same regularity as in blowing bellows, and as is seen in natural breathing, which you are imitating. If another person be present, let him with one hand, by means of a dry piece of linen, hold the tip of the tongue out of one corner of the mouth, and with the other hand grasp both wrists and pin them to the ground above the patient's head."

Sylvester's Method.—The patient, with all tight clothing and bands removed or loosened, is placed on his back on a flat surface, his head and shoul-

ders being supported by his coat or some other garment folded into a broad cushion. The mouth being cleared from all foreign substances, the tongue is drawn forwards, and secured to the chin by a piece of tape or string tied around it and the lower jaw; or the tongue, with a piece of linen, or a pocket handkerchief, around it, may be pulled forwards and held by an assistant. Now, the operator, kneeling at the patient's head, grasps the arms at the elbows, and carries them first outwards, and then upwards, till the hands are brought into contact with each other above the head; they are kept in this position for two seconds, after which they are brought slowly back to the sides of the thorax, and pressed gently against it for two seconds. These movements are gently and deliberately repeated fifteen times in a minute, until a spontaneous effort to breathe is made, or until it is evident that further exertion is useless.

Marshall Hall's "Ready Method."—To clear the mouth and secure free entrance to the larynx, the patient is turned on his face, with one wrist under his forehead and a folded coat or other article of dress beneath his chest. Respiration is now to be imitated by "turning the body gently on the side and a little beyond, and then briskly on the face, alternately." Each time the body is brought into the prone position, firm compression is to be made on the posterior aspect of the thorax. As in the methods already described, the manipulations designed to imitate respiration are repeated fifteen times in a minute, for two or three hours, unless resuscitation is sooner accomplished.

The efforts of the operator should not immediately cease when the first natural respiratory movement is detected, but they should be continued in such a way as to coincide with the spontaneous inspiratory and expiratory motions, until the breathing becomes regular. Other agencies, such as aqua ammoniæ passed back and forth beneath the nostrils, cold water dashed on the surface of the body, etc., may aid in exciting respiration. The temperature of the body may be restored by friction applied by the hands of assistants to all parts of the surface, by the hot-water or hot-air bath, warm coverings, etc. As soon as the patient becomes capable of swallowing, he should be given hot coffee or tea, or brandy or whiskey properly diluted. After respiration has become normal, the patient must be closely watched, in order that the first signs of secondary apnœa may be instantly detected, and that suitable measures to avert it may be promptly adopted.

Vaccination.

Vaccination is a minor surgical operation which every practising physician is expected to be able to perform when occasion demands. Although in itself exceedingly simple, yet, unless the operation be carefully done, failure to afford that protection against smallpox which is reasonably expected, is liable to result. Vaccination may be safely employed in the case of any healthy individual, at almost any period of life. Children should be vaccinated before they are three months old, unless there be special contra-indication to the procedure; and, in the event of exposure to smallpox, even at an earlier age—immediately after birth if necessary. Vaccination may be effected by the use of two kinds of lymph, humanized and bovine. *Humanized lymph* may be used in one of two forms, either as a viscid fluid taken from a well-formed vaccine vesicle on the eighth or ninth day, or as a scab or crust which has separated spontaneously about the twentieth day. The former is generally considered more effective than the latter, yet the dried scab is more commonly employed in this country. *Bovine* or *animal virus* is obtained directly from

the udder and teats of the cow, and is made available by being allowed to dry on slips of ivory, quill, or whalebone. Humanized lymph in either form must be free from blood and pus, and, when kept for use, must be preserved from the action of heat and moisture; otherwise its employment may be productive of serious results. In this country, the suppliers of animal virus envelop the charged ivory and quill points in antiseptic cotton, which is surrounded with water-proof material.

The only instrument needed for effecting vaccination is a common lancet, one which is somewhat dull being usually preferred, as drawing less blood. By means of this simple instrument, the operation may be done quite as satisfactorily as with any of the many ingenious devices which have been suggested for the purpose. That the lancet may not be the means of carrying contagion, it should be kept perfectly clean. The place usually selected for the insertion of vaccine virus, is on the outer side of the left arm, near the attachment of the deltoid muscle, although the operation may be performed on almost any part of the body. Whenever practicable, *arm-to-arm vaccination* is to be preferred to all other methods. In this mode of proceeding, fluid lymph is taken directly from a well-formed vesicle on the eighth day, when its contents are probably the most effective, and inserted into the skin. If *ivory or quill slips* be used, the dried lymph must be softened by holding the points in the steam of hot water, or by dipping them in warm water; or, if the *crust* be employed, it must be reduced to a semi-liquid condition with a little water or glycerine.

There are several ways in which vaccine virus may be inserted into the skin, any one of which, if carefully practised, will undoubtedly prove successful. Probably, the one most commonly employed in this country is that of *abrasion* or "*cross-scratch;*" it certainly seems to be the method most usually successful when dry lymph is used. In making the abrasion, the operator grasps the left arm of the patient in such a manner as to put the skin overlying the insertion of the deltoid muscle on the stretch. He then with the lancet scratches off the epithelium and exposes the absorbing surface of the cutis vera; the appearance of bloody oozing is an indication that the cutis has been sufficiently denuded. On this surface, after the blood has been wiped off, the lymph is smeared, either with the flat surface of the lancet-blade, or with an ivory or quill point. The part is to be left uncovered till the lymph dries. There is no need of making any topical application subsequently; the only precaution necessary is to keep the part from being chafed or scratched till the scab falls off.

Another plan, peculiarly suited to arm-to-arm vaccination, is to insert the lymph into small *punctures* made in the skin with the point of a lancet. These punctures should be made obliquely from above downwards, and should extend well into the cutis. The virus is introduced on the point of a lancet, or on an ivory or quill point. The valvular character of the wound favors the retention of the lymph. Instead of making four or five punctures as above described, multiple punctures may be made, and the lymph rubbed over the wounded surface; or the lymph may be first smeared on the surface and then pricked in, as in tattooing.

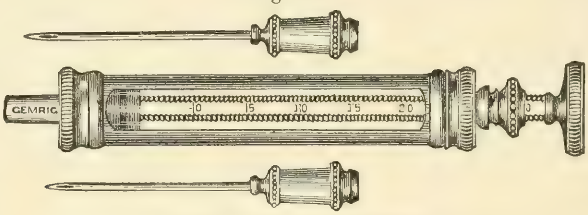
REVACCINATION is imperatively called for in cases in which primary vaccination has entirely failed, or has been modified by causes not apparent. It is also advisable to revaccinate at or shortly after puberty, even when there are unmistakable evidences of a successful and thorough primary vaccination. Some authorities go further, and advise a repetition of the operation once in seven years, and likewise whenever an epidemic of smallpox is prevailing. The methods by which revaccination is effected differ in no way from those adopted for the primary operation.

Hypodermic Injections.

Hypodermic injection is a simple method of introducing certain drugs, especially anodynes, into the system, and is frequently resorted to by surgeons in cases in which a more prompt and decided impression is desired than could be obtained were the same remedies administered either by the mouth or by the rectum. Although this operation, in the hands of an experienced person, is one of extreme simplicity, and free from danger, yet unpleasant and even fatal consequences have followed its employment when incautiously performed; hence, as a rule, the surgeon should either do the operation himself, or intrust it to an intelligent assistant.

The instrument employed consists of a small syringe, holding about 30 minims, with an adjustable nozzle, which is a hollow needle. (Fig. 88.) The

Fig. 88.



Syringe for hypodermic injections.

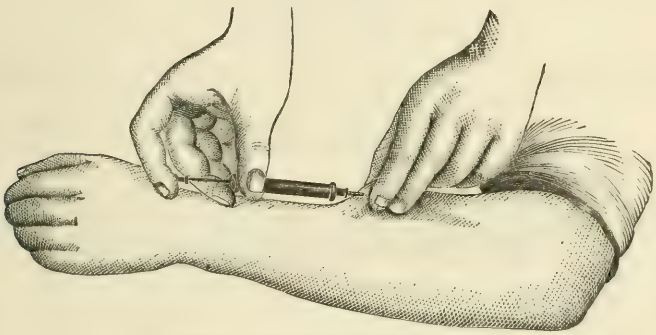
barrel is made of either glass, hard-rubber, metal, or a combination of glass and metal. In order that the syringe may be air-tight, the piston must accurately fit the cylinder; hence the calibre of the latter must be the same throughout. A glass syringe may be graduated to minims, either on the barrel or on the piston-rod; other forms of the instrument have the piston-rod graduated. The perforated needle may be attached to the barrel by either a screw or a socket-joint. The metallic syringe is the one to which the writer gives preference. This has two delicate needles with lancet-shaped points, which are attached to the barrel by a screw-joint. It is provided with a screw-cap that is to be kept on the end of the barrel when the instrument is not in use, in order that the piston may always be moist, and the cylinder free from dirt. A delicate piece of annealed wire, sharp pointed and attached to a small handle, will be found useful to remove dirt or moisture from the needles whenever they become clogged; this may be dispensed with, however, if the operator will introduce a fine wire into the needle immediately after it is used. Hard-rubber syringes, with gold or platinum needles, are best suited for the injection of certain mineral substances, and particularly iodine.

The drug most commonly employed by the surgeon for subcutaneous injection, is the sulphate of morphia. When it is extensively used in this way, as in hospital practice, Magendie's solution will be found the most convenient preparation, for eight minims of this solution represent about a fourth of a grain of the sulphate of morphia. As, however, the solution soon loses its strength by the development in it of a penicillum, and is thereby rendered unfit for hypodermic use, it is a better plan, in private practice, for the surgeon to carry the drug in powder, and to make a fresh solution whenever occasion demands its employment. The writer is in the habit of carrying morphia in quarter of a grain powders, put up in tinfoil. When an injection is to be given, one of these powders may be quickly dissolved in ten or twenty minims of fresh water, the quantity of the liquid being accurately determined by being drawn first into the syringe and then injected into a spoon. The

other alkaloids, viz., atropia, strychnia, ergotina, pilocarpin, etc., cannot be managed in this way, hence they are kept in solution ready for use. Whatever drug is injected beneath the skin, its solution should be free from foreign matter, and as nearly neutral as possible, so that it will not excite undue irritation of the tissues. Of course, this caution does not apply to those injections that are sometimes employed for the express purpose of exciting irritation, as in the treatment of enlargements of the thyroid body, bursal enlargements, cases of neuralgia, etc.

In giving a subcutaneous injection, the operator pinches up a fold of integument between the thumb and first two fingers of his left hand, and, holding the charged syringe firmly in his right, quickly thrusts the point of the needle into the superficial fascia parallel with the fold. (Fig. 89.) The needle

Fig. 89.



Mode of giving a hypodermic injection.

should be carried fully two centimetres (three-fourths of an inch) into the tissue, and its point should be moved about, to make sure that it is not in the deeper layers of the true skin. The contents of the syringe should be forced out slowly, after which the needle should be quickly removed, and the puncture closed by the pressure of the finger for a few seconds, to prevent the escape of any of the fluid, and to arrest the slight bleeding which sometimes follows the operation. Should the patient be timid and dread the slight pain of an injection, the sensibility of the skin may be diminished by the use of local anæsthesia, or the same end may be accomplished with less trouble by firmly pinching the fold of integument as the needle enters the skin. As a rule, the fluid should be injected into the superficial fascia; in some cases of paralysis, however, in which strychnia is employed, the injection is made directly into the affected muscle, and deep injections of chloroform or ether are resorted to in some cases of neuralgia. The pain and redness which occasionally follow a hypodermic injection, may be allayed by the application of a cold compress, or of one saturated with lead-water and laudanum.

Certain localities should be avoided in practising hypodermic medication; these are salient points of the skeleton, the immediate vicinity of large superficial veins, and parts which will be necessarily subjected to pressure. It is not well to give subcutaneous injections in parts that are inflamed. The places usually selected for the injection of anodynes are the outer surface of the forearm and the anterior surfaces of the arm and thigh.

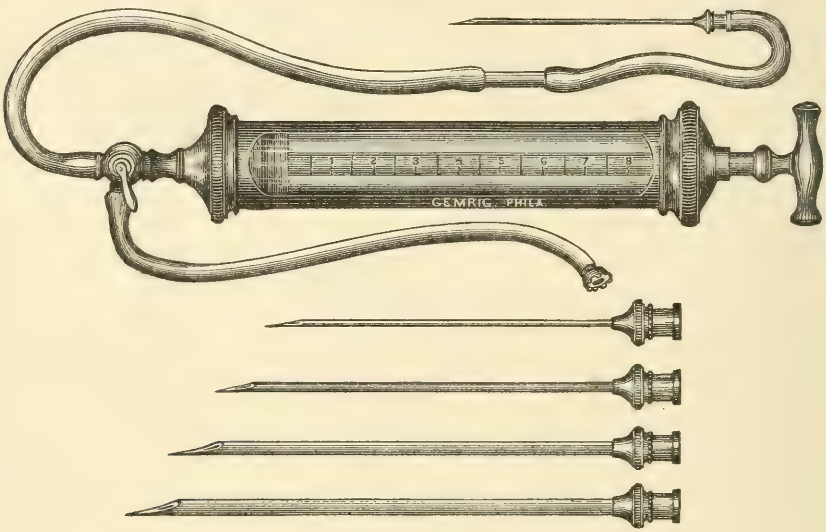
Aspiration.

This operation, which consists in removing the liquid contents of a cavity without the admission of air, is performed by means of an apparatus called

an aspirator. The two varieties of the apparatus in common use at the present time are designated by the names of the inventors, Dieulafoy and Potain. Formerly aspiration was confined principally to the evacuation of fluid collections in the chest; the instruments employed for this purpose were the piston-trocar and the suction-trocar, the latter having been perfected by Dr. M. Wyman and Dr. Bowditch. These instruments are seldom used now, experience having demonstrated that, although simple in construction and easily managed, they are not as efficient as either of the two forms of apparatus previously mentioned.

M. Dieulafoy's aspirator consists of an exhausting pump, composed of a glass cylinder partially incased in metal; a set of sharp-pointed canulæ of various sizes; and two pieces of flexible tubing. The nozzle of the pump has a short tube connected at its side, at right angles, a stopcock at the junction controlling both tube and nozzle. (Fig. 90.) A canula is attached

Fig. 90.



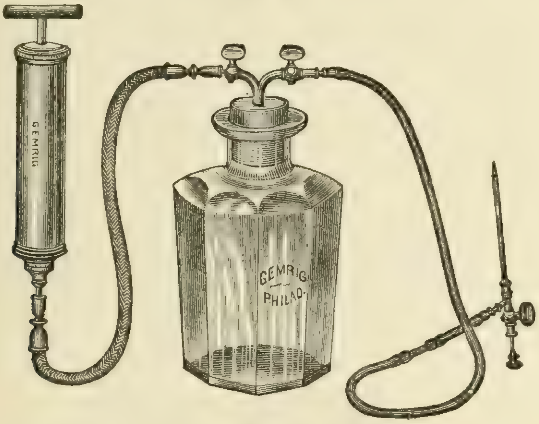
Dieulafoy's aspirator.

to the nozzle by one of the pieces of tubing, the other piece of tubing being connected with the side-tube, and its free end placed in a basin partly filled with water. The canula is quickly thrust into the cavity to be evacuated; and when the stopcock is turned so as to open the nozzle and close the side-tube, and the piston of the pump is slowly drawn up, the fluid rushes into the pump to fill the vacuum. On reversing the stopcock so as to close the nozzle, and pushing down the piston, the fluid is driven through the side-tube into the basin of water. These manipulations are repeated till the cavity is emptied.

The other form of aspirator, devised by Potain, is a modification of the one just described, and is probably superior to it in many respects. The parts of this apparatus are an air-pump; blunt canulæ of various calibres, with blunt and sharp-pointed stylets; an India-rubber stopper perforated with two curved tubes, each having a stopcock; a bottle; and rubber tubing. (Fig. 91.) The stopper is conical in shape, and of a size rendering it adaptable to the necks of ordinary bottles varying in capacity from a pint to half a gallon or more. The bottle is first exhausted of air by the air-pump; then the canula, inclosing the sharp-pointed stylet, being attached to one of the tubes in the stopper by a piece of flexible tubing, is pushed

through the integuments into the cavity containing the fluid to be evacuated. On withdrawing the stylet and opening the stopcock, the fluid passes quickly into the bottle. If there be more fluid than one bottle will hold, the stopcock of the tube connected with the canula may be closed, the stopper

Fig. 91.



Potain's aspirator.

removed, and the bottle emptied; it is then to be re-exhausted by the air-pump. Occasionally, as in the case of cold abscesses, the flow of pus is suddenly stopped by a small mass of lymph or cheesy matter becoming lodged in the canula. Such an obstruction may be easily removed by passing a blunt stylet or plunger through the canula. With Potain's aspirator all unpleasant odors are conveyed with the pus into the bottle-reservoir, and therefore do not escape into the patient's room. This is an advantage not possessed by any other variety of the instrument. As the canulæ of this apparatus are blunt-pointed, they will not wound the delicate inner surface of the sac of an abscess as its walls collapse; hence hemorrhage into the cavity of an abscess is less liable to follow the use of this aspirator than of those that are provided with sharp-pointed canulæ.

In aspirating an abscess, it is advisable to use a large canula, in order that the pus, even if it be somewhat consistent, may escape freely. When urine or serous accumulations are to be drawn off, a smaller canula should be selected. The slight wound made by the stylet or canula should be carefully closed by a strip of adhesive plaster. Although the operation of aspiration is made very simple by the improved instruments now in use, yet certain precautions must be observed to render its performance free from danger. The operator should make himself perfectly familiar with the relation that the bloodvessels and nerves, or other important organs, bear to the cavity containing the fluid, before he proceeds to introduce the canula or needle. Without this special knowledge, he is liable, of course, to do his patient an irreparable injury.

Surgical Uses of Electricity.[1]

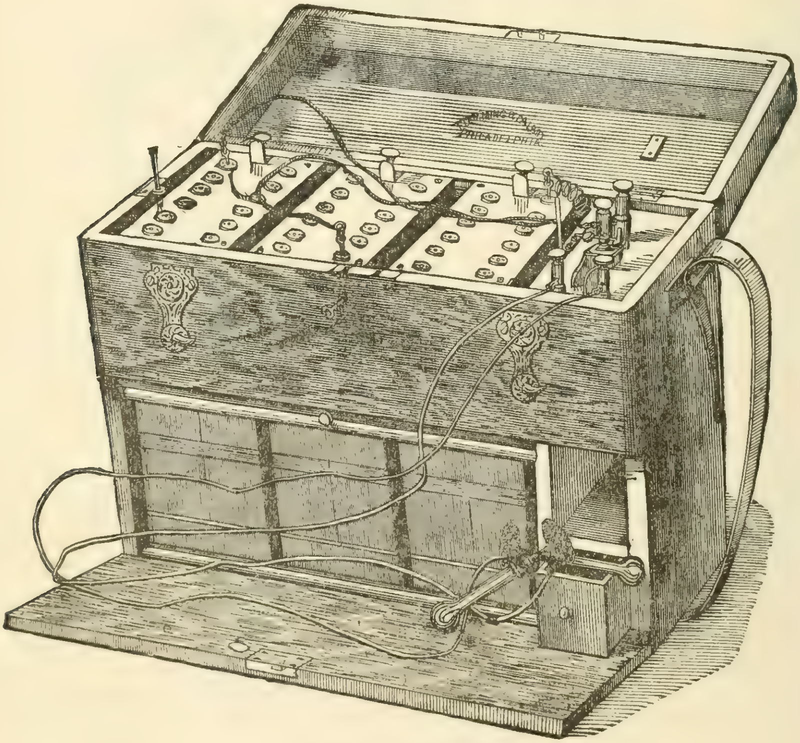
The surgical uses of electricity consist chiefly in the various applications of the operations known as *electrolysis* and *electro-* or *galvano-cautery*. Electro-

[1] The writer takes pleasure in acknowledging his indebtedness to Dr. Charles K. Mills, Lecturer on Electro-Therapeutics in the University of Pennsylvania, for valuable assistance in preparing this section.

lysis means chemical decomposition by electricity, and the term is applied in surgery chiefly to the decomposition by means of this agent of tumors, exudations, or other morbid products. Electro- or galvano-cautery is the process of cauterizing or burning tissues by means of a wire, or other metallic instrument, which has been heated by electricity. Strictly speaking, galvano-cautery is not an electrical operation; electricity is simply used to heat the instrument with which the cauterization is performed. The terms *electro-puncture* and *galvano-puncture* refer to electrolysis, to the plunging of needles into a part through which an electric current is made to pass.

Electrolysis.—For electrolysis, a suitable battery, and needle electrodes of special shapes, are required. The apparatus generally preferred is a galvanic or continuous-current battery of a considerable number of cells of medium size; some form of zinc-carbon battery of thirty or more cells. The fluid that will probably be found most serviceable is the well-known solution of potassium bichromate. Almost any of the constant batteries, however, which are employed in the treatment of diseases of the nervous and muscular systems, can be made use of in this operation. Fig. 92 represents an improved, portable,

Fig. 92.



Constant galvanic battery.

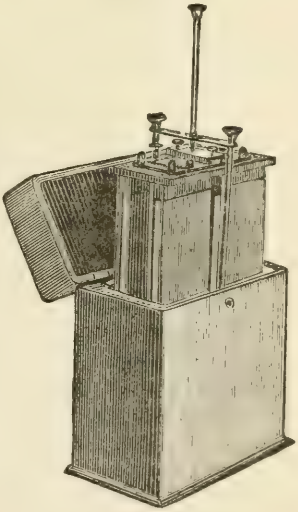
constant galvanic battery, manufactured by Messrs. Flemming and Talbot, of Philadelphia. This battery contains thirty cells; others ranging as high as sixty cells are made. Electrolysis has been resorted to with more or less success in the treatment of aneurism, tumors, and conditions dependent upon old inflammatory deposits The forms of tumor that have been treated electrically are nævi, goitres, polypi, cysts, hydatids, fibroids, epitheliomata, scirrhous cancers, etc.

In the treatment of aneurism, two methods are employed. One method is to insert the needle, connected with only one of the poles of the battery, into the sac, the other rheophore being applied to the surface of the body. In the second and better method, two fine, sharp needles, carefully insulated nearly to their extremities, and connected with the conducting cords from both poles of the battery, are introduced into the aneurismal sac. At first a weak current is allowed to pass, its strength being gradually and cautiously increased as the operation advances. The operation should be performed slowly, as clots that are rapidly produced are liable to be washed away by the blood current. At the expiration of a period varying from half an hour to an hour, the needles are to be removed, and the punctures closed by small compresses of lint secured by plaster or collodion. In some cases it will be found necessary, in consequence of the timidity of the patient, or of pain, to resort to anæsthesia either local or general.

In treating tumors of any kind by electrolysis, the methods are practically the same. As in the case of aneurism, needles either from one or from both poles of the battery are introduced directly into the tumor, in the same way that a hypodermic needle would be inserted. The cells of carcinomata are said to yield sooner to electrolysis than other cells, just as one body may decompose more readily than another. Some electro-therapeutists, the two Bruns, for example, consider that the destructive action of the current is strictly and wholly due to the action of the alkali developed at the negative, and the acid at the positive pole. In addition to its uses in cases of aneurism and tumors, it is claimed by electro-therapeutists that electrolysis is serviceable in the treatment of hydrocele, stricture of the urethra, opacities of the cornea, cataract, inflammatory thickenings in and about the ear, etc.

Galvano-Cautery.—Galvano-cautery batteries are made with plates or elements of a large size, but comparatively few in number, and placed close to one another. In this way, "*internal resistance*," as the electrician would say, is reduced, and a current is obtained which will keep a metallic electrode at a white heat. There are many varieties of the galvano-cautery battery, but perhaps the most compact and generally useful apparatus is the Byrne Cautery Battery, an invention of Dr. John Byrne, of Brooklyn, N. Y. Figs. 93 and 94 represent the battery and the necessary appliances, such as handles, écraseurs, knives, moxa, scoops, etc. The galvano-cautery may be employed in nearly all operations in which the actual or potential cautery, or the écraseur, are employed. By its aid morbid growths and diseased parts can be removed with greater expedition, and with less risk of consecutive hemorrhage, than with the ordinary écraseur. When resorted to as a means of applying the cautery in cavities, its action can be more accurately localized than that of the ordinary methods of cauterization; for which reason, many gynæcologists prefer this apparatus to all others in their operations on the cervix uteri and in the cavity of the womb.

Fig. 93.

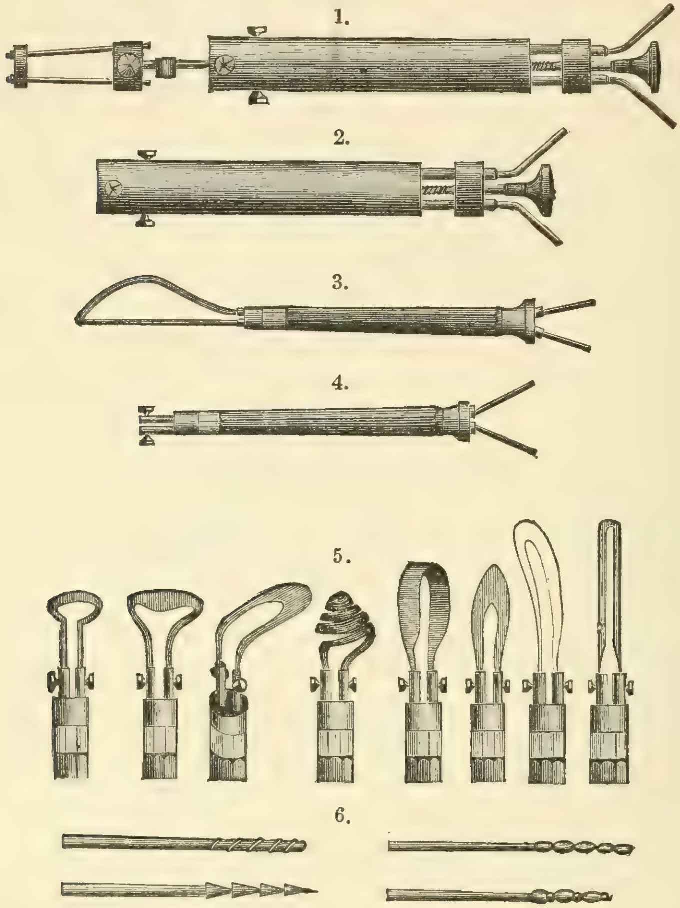


Byrne's cautery battery.

The success attending the use of the galvano-cautery is mainly dependent on the degree of temperature employed. Experience has demonstrated that a dull red heat produces the best results, and hence this temperature should be continuously

maintained during the period of actual cauterization. The main advantage of a galvano-cautery, is that the wire or other electrode can be accurately ad-

Fig. 94.



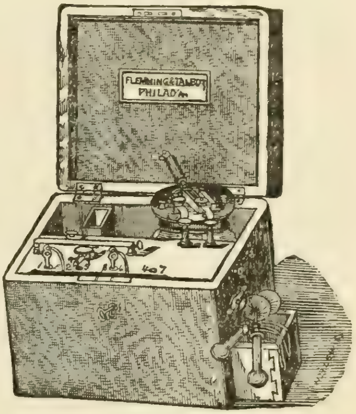
Electrodes for galvano-cautery. 1, Écraseur with wire loop; 2, Handle without écraseur attachment; 3, Cautery knife; 4, Universal hard-rubber handle, 5, Platinum moxas and scoops, 6, Porcelain moxas.

justed in the required position while cold, and then quickly heated. The galvanic écraseur of Middeldorpf consists of a coil of platinum wire which, by its attachments to a rod and a screw, can be shortened as it burns its way through the tissues around which it is placed. Before applying the coil around a diseased mass, as a cancerous nodule of the tongue, it is highly important that the morbid structure should be isolated from the healthy tissues. This is best accomplished by long pins, ivory pegs, or curved needles in handles, passed through the healthy part in different directions. The coil is then placed around the part, behind the pins, and, as it burns its way through, the direction of the section will be determined by that of the pins. [Faure's ingenious "secondary battery," by which the galvanic current can be, as it were, stored away for future use, will probably add very much to the practical advantages of this mode of applying electricity.[1]]

[[1] See British Medical Journal, June 11, 1881, page 914.]

Galvanization and Faradization often prove of service in the various neuralgic and paralytic conditions which accompany or follow surgical affections. In some forms of spinal curvature, and of club-foot, the muscles can be advantageously faradized. Sprains, muscle-strains, and some forms of synovitis, can also with advantage be treated by local faradization or galvanization. Fig. 95 represents one of the best forms of faradic battery.

Fig. 95.



Faradic battery.

Massage.

Under the general term of massage, Dr. W. Wagner, of Friedburg,[1] includes four different manipulations, viz., (1) stroking (*effleurage*); (2) kneading (*pétrissage*); (3) tapping or percussion (*tapotement*); and (4) passive and active motion. To these varieties may be added another form of massage, quite extensively used in this country, which consists in pinching up the integuments and muscles, the latter singly or in groups, and rolling them gently between the thumb and fingers. In the larger cities this treatment is generally intrusted to assistants called rubbers, manipulators, or *masseurs*, who, being specially trained to the art, soon gain great dexterity in its application. Preliminary to the application of massage, the part to be operated upon should be anointed with cocoa-oil or vaseline. If there be a heavy growth of hair on the part, this should be carefully shaved, as otherwise irritation of the follicles and the development of boils may be the consequences of the rubbing.

Stroking (*Effleurage*) consists in gently smoothing or rubbing the surface of a part with the palm of the hand from the periphery; distended veins and lymphatics are thus emptied, and liquid transudation removed from the tissues. In the early stages of inflammation, this manipulation is first applied above the seat of disease, in order to afford more space for the returning currents. By degrees the inflamed part is approached, and, when reached, firm but gentle pressure is made on it, thus forcing the fluids inwards, and promoting the absorption of exudations if they have already occurred. With a diminution in the contents of the vessels, there is a proportionate subsidence of all the local phenomena of inflammation.

Kneading (*Pétrissage*) is a form of massage, applied by rubbing a part circularly with the extremities of the fingers or thumb, or the palm of the hand, and is indicated in cases of inflammatory transudations, and in those of ecchymosis into the subcutaneous cellular tissue. Kneading may with advantage be combined with stroking, whenever it is desirable not only to break up exudation, but likewise to hasten the removal of the resulting detritus from the tissues. The amount of pressure to be used in applying this variety of massage must be determined by the nature and the seat of the material to be gotten rid of, and by the sensitiveness of the patient. A vigorous application of this manipulation is more apt to be tolerated in cases of partially

[1] Berliner klinische Wochenschrift, Nov. 6 und 13, 1876. Boston Medical and Surgical Journal, May 17, 1877.

organized inflammatory products, especially when they are deep seated, than in those of extravasation or serous exudation.

Percussion (*Tapotement*) is another form of massage, which consists in tapping the surface of an affected part either with the tips of the fingers held in a row, a small hammer, or the ulnar border of the hand. Sometimes the palm of the hand is brought into requisition, when a considerable surface of the trunk, as the loins, is the subject of treatment. It is claimed by some authors that percussion will cure, or ameliorate, some forms of neuralgia and of peripheral paralysis, by promoting the absorption of exudation from around the affected nerves. The beneficial effects of percussion in these cases will be greatly increased if the nerves be stretched and the overlying integuments kneaded.

Passive and Active Motion, in conjunction with the manipulations already considered, are found of special service in getting rid of those troublesome conditions so often following sprains, dislocations, fractures, and other affections that require immobilization of the affected limb as an essential feature of the early treatment. While the limb is subjected to stroking, kneading, etc., passive motion of the joints should at first be made by the manipulator, and, as soon as practicable, the patient himself should be encouraged to employ active motion. The persistent employment of passive and active motion will often restore the functions of a stiff joint sooner, and with less suffering to the patient, than the forcible breaking up of adhesions under anæsthesia.

In the treatment of old sprains, and of the later stages of fracture of the extremities, where the muscles have lost tone and become flabby in consequence of disease, Dr. Douglas Graham[1] suggests the employment of what he calls *acto-passive motion*, as a means of restoring the strength of those muscles, and of giving the patient confidence to use them. This manipulation consists in "alternately resisting flexion and extension, while keeping the resistance less than the strength of the limb, so that the patient may not recognize his weakness there."

Muscle-beating.—C. Klemm, Manager of the Gymnastic Institution in Riga,[2] has suggested a form of massage which he terms *muscle-beating*. The instrument that he uses in practising this treatment is called a muscle-beater, and consists of three elastic tubes fastened together near a handle to which they are attached. The circumference of each tube is about that of a finger; the length and the thickness of the material of which the tubes are made vary according to the different purposes for which the instrument is employed—hence muscle-beaters of different sizes are needed. Muscle-beating is not to be made on a naked surface, except in case of the head or the hand; the part should be protected by a thin covering of some kind. The duration of a "séance" should be determined by the impressionability of the part; it is always well to suspend the operation as soon as a sensation of moderate burning, or an increase of the surface temperature, is felt by the patient. The application of this manipulation should be interrupted by slight pauses of a minute or two, in order that excessive irritation of the skin may be avoided.

Among the many diseased or abnormal conditions for which muscle-beating is recommended by C. Klemm, are coldness of the extremities, muscular ataxy, stiffness of the joints consequent upon sprains, dislocations, rheumatism,

[1] Boston Medical and Surgical Journal, vol. xix. p. 578, 1877.

[2] Muscle-beating, or Active and Passive Home Gymnastics. New York, 1879.

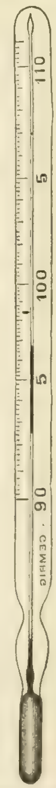
lateral curvatures of the spine, etc. With a little experience in the use of the muscle-beater, an individual may apply the treatment to his own person, and thus dispense with the services of a professional masseur. Many of the benefits arising from active exercise will be experienced by an individual who can practise muscle-beating in his own case; hence it is a good plan, when practicable, for the physician to instruct his patient in the method of employing this manipulation.

Massage should not be applied just before or immediately after eating; an hour midway between breakfast and dinner, or lunch, seems the most suitable. If two sittings a day are deemed necessary, the second should be at a corresponding period between the midday and evening meals. The treatment should be applied at least once a day; some cases are undoubtedly benefited by two applications in the twenty-four hours. The duration of a sitting will depend on the circumstances of each case; an hour may be considered the maximum.

Use of the Thermometer in Surgery.

For clinical observations, two thermometer scales are in common use, the Centigrade and Fahrenheit; the former is used in almost all countries except England and America, where the latter is preferred. As these thermometers are specially designed for detecting abnormal variations of bodily temperature, their scale has a limited range, usually a few degrees above and below the normal temperature, which amounts to $98\frac{3}{5}°$ F. = 36° C. The degrees, and their subdivisions into fifths or tenths, are either etched on the stem of the instrument or marked on a plate of ivory that is attached to the stem. There are many varieties of thermometers in use, but the straight, self-registering, *clinical thermometer* (Fig. 96) has been proved by experience to be the best. In this variety, the upper part of the column of mercury is separated by a small bubble of air. This detached piece of mercury is called the index, from the fact that when it is pushed up by the main column, it remains in position, and indicates the degree of temperature. Thermometers are now made with a "convex face" between the etched lines and the figures of the scale, this serving to magnify the column of mercury, and thus enabling the observer to note quickly the position of the index. Before using this instrument, the index must be shaken down to a point two or three degrees below the normal temperature. This is done by holding the thermometer in the hand with the bulb downwards, and either striking the ulnar border of the hand which grasps the instrument forcibly against the radial border of the other hand, or raising the hand from the body and bringing it down with a quick motion or jerk. There should be a slight constriction between the stem and the bulb of the instrument, to prevent the index from passing into the bulb when it is shaken down.

Fig. 96.



Clinical thermometer.

As accuracy of registration is of prime importance in the use of a thermometer, every instrument ought to be compared with some recognized standard. English thermometers are compared with the standard at Kew Observatory, and if any variation be detected, no matter how small, it is noted in a certificate which accompanies the instrument. A like arrangement is provided for

testing American thermometers, at the observatory at Cambridge, Mass. Should it not be convenient to make the comparison with some standard, the variation may be approximately determined by taking the temperature of a healthy person. One thermometer should not be substituted for another in making a series of observations in the same case.

The temperature may be taken in the axilla, the mouth, the vagina, or the rectum. For obvious reasons, the axilla is usually selected, although the mouth is equally convenient for taking the temperature. The rectum or the vagina should never be chosen for taking a thermometric observation when the other regions are accessible. Before taking the temperature in the *axilla*, all clothing encroaching upon this space should be removed, and any moisture that there may be on the surface wiped off. To raise the temperature of the axillary space to that of the body, the arm should be kept close to the side of the chest for two or three minutes; if this be done beforehand, the instrument will not have to be left in place as long as it would otherwise. The bulb of the thermometer is then put in the centre of the axilla, well under its anterior margin, and the arm brought to the side of the thorax with the forearm across the body. The patient should keep his arm and forearm in this position for at least five minutes. In the case of an infant or a very feeble patient, the arm should be held pressed against the body. If the thermometer be self-registering, it may be removed and the position of the index noted, at the expiration of the time mentioned; otherwise the instrument must be examined before it is taken out of the axilla.

If the thermometer be introduced into the *mouth*, the patient should be directed to keep his lips tightly closed around the stem of the instrument, and to breathe through his nose. Whenever a series of thermometric observations is made in a case of disease, it will be found convenient to use, for noting the daily variation, some form of register or chart which may be kept for reference.

Fig. 97.

Surface thermometer.

The fact that there is a normal, diurnal fluctuation in the temperature of a healthy person, which is not influenced by external circumstances, must not be lost sight of whenever an attempt is made to determine the effects of disease in causing variations of the bodily heat. In a state of health, the temperature steadily rises from morning till towards evening, after which it gradually sinks again till morning. There is a difference of from 1° to 2° F. between the morning minimum and the evening maximum. Exercise and the ingestion of food have the effect of raising the temperature slightly, but rarely more than one degree. The temperature in middle age is a little lower than in childhood, or in the later periods of life. Whenever it is essential to ascertain the amount of daily exacerbations of temperature, two observations should be made: one in the morning between 6 and 8 A. M.; the other in the evening between 4 and 6 P. M.

In practising *surface-thermometry*, instruments having bulbs of discoid shape, or drawn out in the form of a spiral or coil, are generally employed. In Fig. 97 is represented a convenient form of surface-thermometer; this instrument has a stem and graduated scale like the ordinary axillary thermometer, but its bulb is a glass coil, surrounded by a band of hard rubber which protects it from injury and prevents loss of heat. In some localities, as in the intercostal spaces and the vicinity of many joints, the ordinary axillary thermometer, owing to the shape of its bulb, can be used to better advantage than any of the surface-thermometers. To determine accurately the amount of variation in the

surface temperature of a part, it is essential that the temperature of the corresponding part of the opposite side, and the general temperature of the body, should be taken at the same time.

Use of the Sphygmograph.

By means of the *sphygmograph*, the pulsations of an artery may be automatically registered. Although the idea of making an artery record its own pulsations is not a recent one, yet the practical realization of this conception of Galileo dates from the invention of the sphygmograph by Vierordt and Marey.

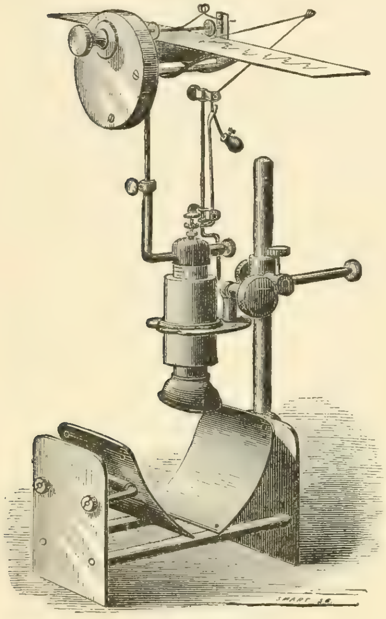
Two forms of this instrument are in use at the present time: M. Marey's, modified by Dr. Mahomed, and Dr. E. A. Pond's; the former in England and on the continent of Europe; the latter principally in America. Marey's sphygmograph consists of a brass framework to which are attached an arrangement of levers designed to be acted upon by the pulsating artery, and a clockwork which propels a slide carrying a piece of paper or mica on which the pulsations are registered. To regulate and measure the amount of pressure made on the artery by the mainspring, Dr. Mahomed has had attached to the side of the framework an eccentric wheel, which acts upon the mainspring, and is worked by a thumb-screw. The degree of pressure exerted upon the mainspring by the eccentric is indicated on a dial-plate. The pressure is measured in troy ounces, from one to eighteen; the amount of pressure employed in taking a tracing should always be recorded on the slip with the latter. Preparatory to taking a tracing, the forearm of the patient is laid, with the palmar surface upwards, on a splint or some other convenient support, as on a double-inclined pad with an angle of about 135°, with the hand bent slightly backwards. The sphygmograph is placed on the forearm with the ivory pad at the free extremity of the mainspring, directly on that portion of the radial artery which lies to the inner side of the styloid process of the radius. When the instrument is properly adjusted, it is secured by straps buckled around the limb. In order that a satisfactory tracing may be obtained, the hand must not be too much extended, nor, on the other hand, should it be tightly closed. In the former position, the pulsations of the artery are liable to be interfered with by the vessel being stretched over the surface of the bone; in the latter, the tendons adjacent to the artery are made tense, and rise above its level, thus preventing the pad from coming in contact with the vessel. With the instrument properly adjusted, it is necessary to determine the amount of compression that must be made by the pad on the artery, in order to give the greatest range of movement of the recording lever; this may be done by means of the graduated thumb-screw.

The paper on which the tracing is to be made should be enamelled on both sides, and smoked on one. It may be smoked by holding it over the flame of a small piece of burning camphor, or over a little mass of ignited cotton saturated with olive oil, or over a smoking paraffine lamp. Slips of mica may be smoked in the same way. A slip thus prepared is placed on the travelling slide, with the point of the recording lever in contact with the blackened surface. By touching a button connected with the clockwork, the latter is set in motion, and the slide carrying the slip is steadily moved along.

The sphygmograph invented by Dr. E. A. Pond, of Vermont, has many advantages which recommend it as superior to all other forms of the instrument. It is compact in size and very easily adjusted to the principal arterial

trunks of the extremities, and furnishes tracings of a delicate and reliable character in a very short time. The improved form of Dr. Pond's sphygmograph does not require a splint or other support for the part to which the instrument may be applied. The pulsations of an artery are communicated to the expanded extremity of a vertical lever, inclosed in a tube that is closed below by a diaphragm of thin rubber. This lever is connected with a system of levers which serve to move a pendulum-jointed needle which records the arterial pulsations on a slip. A watch-movement attached to the vertical tube by an upright moves the tracing-slip on a fixed horizontal slide. A pressure-gauge, graduated from one to sixteen ounces, is attached to the tube containing the vertical lever, and indicates the amount of pressure made on an artery when a tracing is being taken. (Fig. 98.) A slip of enamelled paper or mica, prepared as has already been described for receiving a tracing, is secured on the slide by setting free the watch-movement; when the slip has been carried along about a quarter of an inch, the watch-movement is stopped till the sphygmograph is adjusted. The operator then places the instrument over the artery (usually the radial, just within the styloid process of the radius), with the button-like extremity of the vertical lever impinging upon the vessel, and holds it steadily in this position while the tracing is being taken. The amount of compression that will give the maximum movement to the needle on the slip may be ascertained by observing the pressure-gauge as the pressure on the artery is varied; this degree of compression should be maintained during the operation. With the instrument properly adjusted, and the tracing-slip in position, the watch-movement is to be liberated—to be again stopped when the slip has been propelled over the platform.

Fig. 98.



Pond's sphygmograph.

Should it be desirable, sphygmographic tracings can be readily preserved by varnishing them. To make them of service for future reference, the name of the patient, the date of the observation, and the amount of pressure made on the artery, should be inscribed on the blackened surface of each slip by means of some sharp-pointed instrument, as a needle or pin. The varnish recommended by Dr. A. E. Sansom is composed of gum benzoin, one ounce, and methylated spirit, six ounces. Dr. Pond prefers one consisting of alcohol, one pint; gum sandarac, three ounces; and castor oil, half an ounce. The slips, after having been inscribed, are carefully dipped in the varnish, and allowed to dry.

PLASTIC SURGERY.

BY

CHRISTOPHER JOHNSTON, M.D.,

EMERITUS PROFESSOR OF SURGERY IN THE UNIVERSITY OF MARYLAND, BALTIMORE.

THE Surgical Art Formative (πλάσσειν to form) boasts of a high antiquity, and was resorted to in remote times, as at present, to repair, remedy, or conceal the ravages and disfigurements of disease, as well as to lessen the deformities produced by the execution of judicial decrees, by natural defects, or by the accidents of personal or general conflict. That branch of this department of surgery which has for its object the restoration of noses, very probably antedated the other branches, as the records of Indian and Egyptian surgical art seem to indicate; but while the subdivisions of the art multiply, as various organs or parts are concerned, the principles governing all plastic proceedings remain the same. The synonyms of this department of surgery are numerous; thus, Chirurgica Plastica; Morioplastice, from μοριον "a part," and πλάστικος "forming;" Transplantatio; Chirurgia Anaplastica and Chirurgia Autoplastica—names preferred by Velpeau and Blandin, and derived from the Greek, the one from ἀνά "again," and πλάσσειν "to form," that is, to fashion anew; the other from αὐτός "one's self," and πλάσσειν "to form," to form of, or out of, one's self, or "self creation" (Gross)—whence the words Anaplasty, Autoplasty; and finally PLASTIC SURGERY, or that province of surgery which is distinctively formative.

Among the foregoing appellations I revert to *Transplantatio*, which signifies absolute removal from one part and implantation into another, to point out that such transplantation of larger portions of the body has been designedly accomplished, or an accidentally ablated part successfully reapplied, or blood transfused—all instances of total separation before adjustment, or, in the case of the blood, of perfect abstraction and introduction into the circulatory system of another individual; and that the same end has been mediately effected as in Roux's operation, that of "Autoplasty by successive migrations of the flap." And I would associate with these instances of union of larger surfaces, or multitudes of germs, the modern operation of Reverdin, known as *skin grafting*, by which extremely small portions of integument, and even epithelial elements scooped from the rete, after being totally separated, are implanted or "grafted" upon the surface of tardily healing ulcers, as of burns. Adhesion soon occurs, and is followed by proliferation around the transplanted germs, whether these have been derived from the subject himself, or from another person; whether they are pigmented or otherwise. The transplantation of the spur of the cock, from the leg to the comb, is a familiar example of this mode of procedure, as is also the translated flap of Roux; but in these instances, vitalized adherence terminates the process; whereas, in the case of skin grafting, as practised by Reverdin and

others, the stranger germs are extremely few in each grafted particle, but they form the centres or foci of a cell-formation which gradually but surely spreads and closes over the reluctant surface.

History of Plastic Surgery.

Though we cannot fix the exact period at which plastic surgery was first practised, yet we may be sure that it must have followed with a kindly hand the barbaric use of power and the cruel resentment which were displayed at an early period of the world's history, especially in India, in the mutilation of offenders by the lopping off of ears and noses. And in ancient Egypt, also, Rhinoplasty was known and practised, as Galen declares, and as may readily be believed if we accept as indirectly confirmatory, the Ebers Papyrus, "the Hermetic Book of Medicines of the Ancient Egyptians, in Hieratic Writing," of unknown authorship. And it is also interesting to observe that in the "Secret Book of the Physicians" the science of "the beating of the heart and the knowledge of the heart" are referred to, as taught by the priestly physician, Nebsect. Ebers believes the Papyrus to have been a compilation made by the College of Priests, at Thebes; and assigns the writing to the middle of the sixteenth century, or more precisely to the year 1552 B. C. This date, as is commonly supposed, was prior to the departure of the Israelites, and, according to generally accepted chronology, Moses, in 1552 B. C., was just 21 years of age.[1] The same author, Professor Ebers, of Jena, in an original work "Ouarda," in which he assures the reader that all his statements are based upon authority, besides furnishing evidence of the high position reached by Medicine in the reign of Rameses II., alludes to its division into twenty-one specialties, such as are accepted and practised at the present day, and gives prominence to the thoroughness with which the science and art were studied and practised by the priest-physicians of a great era in Egypt's history. The Roman Hippocrates, Celsus, who livid about one hundred and fifty years before Galen, in the reigns of Augustus, Tiberius, and Caligula, speaks of the restoration of the ears, the nose, and the lips, by the aid of the neighboring skin, and also of reparation of the prepuce. Galen says but little of the treatment of mutilations, and this is copied by Paulus Ægineta and others of his followers. Antyllus mentions coloboma and its repair. And Malgaigne, in his introduction to Paré's Surgery, refers to an Italian family, named Branca, as conservators of the art of restoring noses during the middle ages, and as having invented new methods.

In the year 1597, at a time when learning received a new impetus, appeared the very remarkable and erudite work of Gaspar Taliacotius, entitled "De curtorum chirurgia per insitionem," in two volumes, published in Venice. In this treatise, Tagliacozzi, besides describing minutely the operations for restoring or repairing multilated lips and ears, gives special prominence to his original method of reproducing noses, in which the flap is taken from the arm, and which has ever since borne the title of the *Taliacotian* or *Italian* operation to distinguish it from the *Indian* or *Oriental* operation, in which the flap is obtained either from the forehead, the cheek, or even the nose itself. The Indian operation was first put in practice in London, in 1814, by Carpue, and afterwards in Germany by J. F. Dieffenbach, who, at the end of the first third of the century, gave great development to the subject, to which he drew attention by the publication of his experiences and of his improved methods. Subsequently, in France, Blandin, Jobert (de Lam-

[1] Charles Rice, in N. Y. Daily Tribune, Nov. 9, 1875.

balle), Serres, Roux, Denucé and Verneuil; in Belgium, Burggraeve and Verhaege; in Germany, Zeiss, Von Ammon, Hoffacher, Baumgarten, Langenbeck and Schuh; in England, Liston, Pollock and Spencer Wells; and in the United States, J. M. Warren, Pancoast, Mütter, Gurdon Buck and others, both by their writings and practice have made themselves deservedly eminent, and, occupying a high position, have placed both the profession and the public under obligation. In reviewing, however, the copious bibliography of plastic surgery, I deem it not unfair to give a well-earned prominence to American Surgeons, whose ingenious and felicitous operations and practical treatises and contributions to science have established the reputation of their authors upon an enviable and enduring basis.

Lesions Remediable by Plastic Surgery.

The term Plastic Surgery, says Verneuil, "signifies, then,[1] in surgical language, the repair or restoration of an organ changed in form, by the aid of a loan effected in the patient himself, and made at the expense of neighboring or distant healthful parts." "It remedies deformities of deficiency or excess by operations of *anaplasty by autoplasty*, which term ought to be restricted to cases characterized by a deficiency of substance as a lesion, and by an organic borrowing from the same subject as an operation. And this double character serves (1) to establish differences between the method in question and the other anaplastic methods, and (2) to distinguish *autoplasty*, properly so called, from *heteroplasty*, which borrows substance from a stranger organism, and from *prothesis*, which replaces lost parts with artificial ones made out of inorganic materials."

It is evident that the occasion for the operations of plastic surgery must arise from congenital defects or deficiencies, from atrophy or wasting after birth, or from actual losses of substance, whether by disease or traumatism. And it is equally obvious that different causes may bring about the same result—deformity—as in the cases of excision of a bone and its congenital absence; the loss by mutilation of part of an organ, as a muscle, and its atrophy from lesion of its tutelary nerve; and the total loss of substance produced as in the cutaneous structures, by traumatism upon the one hand, and by disease upon the other. It is unfortunate that in many deformities, such as arrests of development and total deficiencies of parts, the condition is irremediable; in some, however, plastic surgery alone may make amends; whereas in others this reparative art needs the aid of artificial appliances or substitutes which enlightened surgery must perforce employ. And here, before going further, I would call attention to the absolute necessity for accurate diagnosis; for the positive recognition and determination of the nature of the cause or lesion, and of the actual condition of the part or organ. Whatever be, in general, the need for precision in matters surgical, anticipating operative procedure, there is no department of the art in which a correct appreciation of the causes and consequences of deformity, or lesion, leads to better courses and results in practice.

Plastic surgery deals, then, with deformities congenital or acquired. Among the former are to be ranged atrophies, arrests of development, and intra-uterine mutilations, which latter sometimes involve a part or the totality of a member; and, further, to quote Verneuil, who himself cites Geoffroy Saint Hilaire,[2] as saying that congenital deformities are more frequently met with at the

[1] Verneuil, Art. *Autoplastie.* Dict. Encyc. des Sciences Médicales. Paris.
[2] Tératologie. Paris, 1836.

periphery of the body. "Surgeons may make the same remark." "Arrest of development, atrophy, or mutilation of central parts, compromise life much more certainly than the same lesions affecting the members, the tegumentary folds, the nose, lips, penis, ear, etc." The further remarks of Verneuil upon deformities, considered with a view to their relief by plastic surgery, deserve notice in this place, as also his classification of the lesions to which this branch of the art of surgery "has been most happily applied."

"Deformities by deficiency, compatible with life, may be arranged in three categories, reference being had to their radical cure.

"(1) The absolutely incurable. For example, the total or partial absence of a member, bone, or muscle; marked atrophy in an extreme degree; loss of substance, too deep or too superficial, but very extensive, are cases in which autoplasty can do nothing.

"(2) Cases in which autoplasty can only mask, palliate, or mitigate the deformity without being able to restore both form and function; in which, whatever loss is sustained, absence of the part cannot be compensated for by borrowed tissue.

"(3) The last category comprises those cases in which the loss of substance is of small extent, and affects membranous organs only. Nevertheless, even in these cases, the deformity may be repaired without recourse being had to autoplasty; for example, a vesico-vaginal fistula of the bas-fond of the bladder, in which the margins may be simply united. . . . . . . But things are very different if the loss of substance be great, if the skin be naturally adherent to the subjacent parts, if it have lost its flexibility, its mobility, its extensibility in consequence of disease. Here autoplasty becomes a necessity."

And in this place a general view should be presented of the lesions in which plastic surgery has been more or less happily called upon; but finding the enumeration of Verneuil so apposite, we do not hesitate again to draw material from his admirable article quoted above.

"(1) *Perforations* and *fistulæ*, which establish a communication between a cavity, a reservoir, or a mucous canal, either with a neighboring mucous organ or with the exterior of the body.

"(2) *Mutilations, total* or *partial*, of projecting appendices, cutaneous folds, or membranous curtains, which circumscribe the natural apertures.

"(3) *Superficial losses of substance*, not penetrating into cavities, having destroyed a more or less considerable extent of skin or mucous membrane, in a single region, or at the commissures."

And again, the state or condition of the deformities under consideration demands their division into the following categories:—

"(1) Those without tendency to natural repair.

"(2) Those met with or created before natural repair (wounds, the extirpation of tumors).

"(3) Such as present themselves after nature's efforts at repair."

It is evident that in the wide field of action vaguely defined in the preceding pages, surgery has offered to it a great variety of disablements and disfigurements, produced under many conditions, but which may be referred to congenital vices, arrests or absence of development, traumatism *in utero*, or the result of infelicitous use of instruments; to injuries of all kinds; to burns; or to the external manifestations of diseases, and their vicious spontaneous healing with loss of substance, or repair by distorting cicatrices; to gangrene, and to losses produced or provoked by wounds, however inflicted. It is equally apparent that, in dealing with these departures from the normal, the resources of plastic surgery must be taxed, and the aid of artificial substitutes or supports invoked. And not only are these arts exercised upon parts in which disease has done its work, but, as in the rebellious ulcers left

by burns, heteroplasty, manipulating minute flaps or particular masses of germs, attacks by the process of skin grafting, and forces repair in the midst of a tardily granulating surface. Heteroplasty, formation by borrowing from another organism, is also practised in the *transfusion of blood*, by which portions of the blood of man or other animals are introduced into the veins of those who have suffered great losses of the "mother of all the tissues," and who are revived by the refreshing stream. Not only so, but intravenous injections of *milk* have been employed successfully by Prof. T. Gaillard Thomas and others, in cases of very considerable post-partum hemorrhage.

General Principles of Plastic Operations.

When all conditions agree in determining a resort to plastic surgery, no principles which govern this branch of the art should be lost sight of. They are not numerous, but their application under many circumstances of difficulty requires the nicest exercise of judgment, more especially in certain cases in which a plastic operation cannot be repeated. For example, in a case of double harelip which fell under the writer's care, the lateral fissures, on either side of the maxillary bone, extended deeply towards the orbits, and the clefts through the soft parts involved the lip, the cheeks, and the eyelids, and were traced in each eye into a coloboma iridis. In this and similar instances, an error in judgment, compromising much marginal substance, might defeat the present, as it would most probably the final, success of an operation otherwise well devised. The risks, however, of failure in difficult cases, those in which arrest of development has left considerable and intricate spaces, or in which disease or traumatism has produced deformities demanding for their relief an appeal to all the resources of art, are diminished by dividing the proposed operation into a number of lesser operations, or *séances*, so that, like an Alpine mountaineer, the surgeon shall undertake no step forward until abundant security has been obtained for the advance. Thus an original operation, limited in its scope, may be made the foundation of a series of secondary procedures, the success of each of which will render that of its follower less doubtful, and will multiply the chances of a favorable issue for the case.

A comparison of deformities and lesions will serve to arrange them all into two groups, as far as plastic surgery is concerned; the first requiring for its extinguishment or repair simple approximation of parts—widely sundered, it is true, but separated by the unopposed and not vigorous traction exerted by the physical properties of some of its elements, and the vital property of others; the second necessitating a borrowing from the immediate or remote neighborhood, and the localization and interpolation of new flaps or pieces. It may be claimed as self-evident, as it is also shown in practice, that the frequency of fortunate results in the former group is in accordance with the lack or low degree of tension, and with the analogy, or rather identity in nature, of the tissues restored to their original relation, or even, urged a little farther, made to bridge over a gap left by a minor loss of substance. In the latter group, the same absence of stretching or tension must mark the adjustment of flaps, and the same analogy of tissues must be preserved in the selection of pieces to be permanently transposed. Besides all this, it is requisite and necessary that the flaps should be well provided with nutrient vessels, whether they be destined to retain their continuity with the mother tissues, or to lose their original basal attachment by severance as soon as they shall have acquired sufficient adhesion in their new position. It must also suggest itself to the surgeon that hairy parts should not, if possible, be repaired with

bare flaps, and that hairy flaps should not, upon pain of ridiculous disfigurement of the patient, be translated to regions normally devoid of hair. The end of a re-made nose would be an undesirable termination of that organ, if it were made to bear a tuft derived from a well-covered scalp.

Another circumstance tending towards the successful ending of a plastic operation, is recognition of a due proportion between the size of the gap to be filled or bridged over, and that of the flap. And it must be well borne in mind that, as by cicatrization a "natural autoplasty" (Verneuil) is accomplished by the simple traction of the cicatricial tissue, it may be necessary, under different circumstances, to employ a flap smaller, the size of, or much larger than the space to be covered. A flap borrowed from situations in which the tissues are lax, ought to be many times larger than the opening or chasm; for, by the natural elasticity of its elements, the flap is greatly reduced in size, and, inasmuch as it will not bear tension, scantiness of material may lay the foundation of failure in the operation by rendering firm union between the freshened surface and the borrowed piece impossible, and by inviting and producing inflammation and gangrene. Of course, such a condition of things would be a misfortune, since positive and extensive loss of substance in the flap, or destruction of its totality, is usually repaired with difficulty, if even the damage thus occasioned should not preclude the possibility of a repetition of the operation. Wherefore the surgeon must assure himself of the just proportions, as well as of the form, of the proposed flap, making due allowance for shrinkage as well as for ulterior atrophy, which sometimes follows a perfect union. But even here, it may be added that flaps of sufficient thickness, as well as size, and abundantly provided with bloodvessels, are much less liable to ulterior atrophic contraction.

Classification of Plastic Operations.

From what has been said, it will readily be admitted that all plastic operations may be arranged in five categories. The *first* comprises all those in which the borrowed piece is obtained *from a distance* and transferred directly to the seat of its future residence, retaining, however, for a time not determinable with precision, its connection by means of a pedicle with the tissues of its original site; to the *second* belong those cases in which the autoplasty is accomplished, after the method of Roux, by "*successive migrations*" of the flap, from a point more or less remote; the *third* includes all operations in which the flap or flaps are derived from the neighborhood, and are moved into place by *gliding*, or made to assume proper relations by *stretching* or by *lapping over*, as when a periosteal flap is made to cover the end of a severed bone after amputation; the *fourth* embraces all those operations of simple *approximation*, as after the V-shaped piece is removed for the relief of ectropion, or for the attempted cure of epithelioma of the lip, or, more primitively, when the freshened "vivified" edges of a vesico-vaginal fistula are brought into contact, and maintained in apposition with more or less tension. Under the same caption may be inscribed several of the methods for bringing about adhesion in ununited fractures of the bones, the broken ends being, under some circumstances, vivified, and made adherent to one another by means of silver wire, or of a screw or screws of the same metal. Lastly, the *fifth* category comprehends all *readjustments* of totally severed parts, as a nose or a tooth, authentic instances of which species of repair are not sufficiently infrequent to be wonderful. In this category are also to be enumerated the famous skin grafting by *greffes épidermiques*, or *dermo-épidermiques* of Reverdin; the grafting by larger bits, or *anaplasty*, of Sée,

Ollier, and Poncet; the transplantation of particular or greater morsels derived from a stranger organism, *heteroplasty*, whether that be human or animal; and, finally, transfusion of blood.

General Rules for Plastic Operations.

In the majority of the operations and methods enumerated, immediate union, or union by the first intention, of the newly juxtaposited parts, is the aim and hope of the surgeon, although sloughing or gangrene to a small extent may not wholly defeat the intention of the operator. But a scrupulous attention to the general condition and surroundings of the patient, the adoption of a carefully studied plan of operation and observance of its minutest details, and a sagacious and watchful after-management of the case, are circumstances which lead to if they do not insure success, and which must be had in view and closely followed out if success is to be the issue. Among the evil consequences of an unwise disregard of detail, may be mentioned gangrene, as depending upon a poverty of the nutrient supply of the flaps, whether by reason of its attenuate pedicle, its thinness, the scantiness of bloodvessels in the pedicle, or their choking by excessive tension or twisting, or upon want of protection. The manner of making the sutures, the choice of proper material for them, and the distance from each other at which they are placed, will and must influence the mode and time of union of the wedded parts, and bring about, or not allow or favor, union by first intention. And thus portions along the line may fail to heal, and suppuration may permanently interfere with a union which, in other situations, is firm enough. And a disregard for the quality of the air in which the subject of the operation lives, as loaded with the miasmata of fever or erysipelas, or the prevalence of the latter disease as an epidemic, may not only set the operative skill of the surgeon at naught, but may open a door in the patient's body for the entrance of a fatal complication.

In this connection, a very important circumstance ought to be made conspicuous, and this is that the hiatus left by the forced loan imposed upon an innocent feature, must itself be the subject of the same interest which attaches to the locality benefited. It may sometimes be left to cicatrization and ultimate shrinking of the scar, but not unfrequently adhesive straps invite or force approximation of separated margins, with or without preliminary loosening of the integument and connective tissue done with a view of facilitating approach, or linear or crescentic incisions may be employed to transfer deformity to unimportant situations, by promoting instant adhesion of tissue margins separated by loss of substance. It was with this intention that the writer, after removing, by a long elliptical incision, a considerable melanotic tumor from the front of the thigh of an itinerant Methodist preacher, who made his circuits on horseback, practised on either side of the longitudinal gap a deep incision parallel with the neighboring margin, dissected up the bands lying between the incisions and elliptical space, and brought the margins together in a line on the convexity of the thigh. Immediate union occurred along the whole extent of the line, while the lateral cicatrices were so placed as to escape friction from clothing or other matters which the front of the thigh was called upon to bear.

But loss of substance, if it be of limited extent, may not always require the translation of a flap, or may not call for any further abstraction of tissue. Thus for freshening the margins of some buccal fistulæ, experience has shown the advantage to be derived from the employment of the actual cautery, or the thermo-cautery of Paquelin, applied at a dull-red heat and at

several sittings, the operator relying upon the cicatricial contraction produced by the healing of the successive burns, for the extinguishment of the distressing and unsightly aperture.

Among the interesting documents which bear upon this subject, I would refer the reader to one by J. R. Marinus,[1] entitled "Considerations upon Heteroplasty or Autoplasty by Heterogeneous Transplantation," a compendium of remarkable cases of parts restored and replaced. This author quotes Reissiger,[2] as being the first who proposed to replace an opaque human cornea with a healthy one derived from an animal [an operation which has been, of late years, successfully resorted to in several instances]; and afterwards Mæsner, and subsequently Dieffenbach, who both attempted "keratoplasty" upon animals, but whose experiments led them to the conclusion that, since the cornea when nearly separated did not reunite, transplantation to another eye offered still fewer chances of success. And, on the other hand, Marinus assures us that Rudiman reports that in India belief is so strong as to the possibility of reunion of a cut-off nose, that the executioner is commanded to throw the piece into a brazier, to prevent readjustment.

In this country, as is well known, plastic surgery has been much cultivated, and practised with remarkable success. The operations and most valuable contributions of Prof. Joseph Pancoast are guides and texts for surgeons, and the work and practice of Mütter are monuments in this department of the art of surgery, but we would regard this notice as incomplete without reference being made to Prof. Gilbert,[3] among whose successful cases may be mentioned the construction of two noses by the Indian method; to Dr. Gurdon Buck,[4] whose triumphs are familiar in the department of restorations; and to Dr. Detmold,[5] to whom both the profession and the public owe so much.

Skin Grafting.

Under the *fifth* caption we have grouped, and therefore associated together, a number of facts which acquire relationship by reason of the complete separation of the parts re-applied and fixed by restitutive autoplasty, as of the *nose*, of which Hoffacher, officially present at duels with rapiers fought at Heidelberg, reports several successful cases, and notably one in which the organ lopped off was seized by a dog, but being rescued, although cold and moist, was, after careful cleaning, re-attached. Bits of fingers, lopped off, have been known to adhere vitally after replacement, and teeth also have taken hold when transplanted; indeed transplantation of these ornaments of the mouth was, within a century, a fashion in some countries, in which, it is said, sound front teeth of fresh country girls were purchased by fading belles to replace their own carious incisors or canines. It is remarkable that with such experiences, which, perhaps, were not confined to the later centuries, surgeons so slowly recognized the facts, *first*, that portions of the living body might be sundered from it without immediately losing life; and, *secondly*, that these portions, so removed, could contract vital adhesion with another part of the same individual, or with some part of another person or creature. But, like the discovery of the circulation of the blood, the separate anatomical and physiological truths of which were known even from the time of Galen, the

[1] Annales de la Société de Médecine d'Anvers, 1842.
[2] Baier'sche Annalen, 1824, Bd. i., Stück 1, S. 209–215.
[3] Med. Examiner, new series, vol. vii. Philadelphia, 1851.
[4] Bulletin of the New York Academy of Medicine, vol. iii., and elsewhere.
[5] Bulletin of the New York Academy of Medicine, vol. iii. Paper upon Plastic Surgery.

discovery of the phenomena of germination of anatomical particles when transplanted, was reserved for very modern times, although glimpses of the real significance of the process of healing of wounds and ulcers had been enjoyed in early ages.

Perhaps Prof. Frank H. Hamilton, of New York, may be regarded as the first who attempted to generalize upon the experience of the past, when, in his clinique at the Dispensary of the Geneva Medical College, in January, 1847, he proposed to a boy of fifteen years a plastic operation, with the view of planting upon the *centre* of an ulcer a piece of new and perfectly healthy skin, taken from the calf of the other leg, and not intending to cover over the whole sore, but, perhaps, two or three square inches, which he believed would be enough to secure the closure of the wound in a short time.[1] And the reporter affirms that this proposition had been made to the lad two years before. Dr. Hamilton's earliest operation of the kind was not done, however, until January 21, 1854, upon Horace Driscoll, in the Buffalo Hospital of the Sisters of Charity. An account of this operation, contained in a paper entitled "Old Ulcers treated by Anaplasty," read before the Buffalo Medical Association, June 27, 1854, was published in the *New York Journal of Medicine* in September of that year. In the summary, the following remarkable sentence forms the *fourth* of six propositions: "If [the graft be] smaller than the chasm which it is intended to fill, the graft will grow, or project from itself new skin to supply the deficiency." The *fifth* proposition refers to a probable *expansion* of the graft, and the *sixth* asserts that "in consequence of one or both of these two latter circumstances, *it will not be necessary to make the graft so large as the deficiency* it is intended to supply." In this we observe the declaration of a principle, not new in fact, but original in its direct suggestiveness, implying a knowledge of the strength of *border growth* of new skin in an ulcer, of the weakness of the *middle part*, and also of the means likely to repair, or capable of remedying, the deficiency. The fact was known long before, and is still familiar in the text-books of surgery, as we find Erichsen saying, "Indeed, if the ulcer be large, there may not be enough [new skin] for the cicatrization of the centre." What Hamilton accomplished, and no doubt intended, if his words mean anything, was the establishment of a new basis of skin-formation where it was most needed, and his credit does not rest upon the performance of a simple anaplasty.

The generalization of the idea which guided Hamilton was made by Dr. J. L. Reverdin, *interne lauréat* of the Hospitals of Paris, in 1869, for on the 8th of December of that year he presented[2] before the Society of Surgery a patient who belonged to the service of his "excellent master," Dr. Guyon, and on whom he had practised a new experiment, for which he proposed the name of *epidermic grafting.* It consisted, to use his own words, "in transporting to a granulating wound little bits formed out of the superficial parts of the integument."

"This experiment had been suggested to me," he says, in an admirable article published a few years later,[3] "by having observed little epidermic islands which formed spontaneously in certain wounds; I asked myself if, by a graft, we might not obtain the formation of similar little islands of cicatrization, and thus hasten the cure; therein was a double interest, physiological and practical. The result was such as I dared hardly hope; not only did the little morsels continue adherent to the granulations, but presently they began to extend and form an island of cicatrization." And then the author, surveying the field likely to be covered by skin grafting, reproduces a part

[1] Buffalo Med. and Surg. Journal, Feb. 1847, p. 508.

[2] Bulletin de la Société de Chirurgie, 1869; Gazette des Hôpitaux, Janvier, 1870; British Med. Journal, Dec. 10, 1870.

[3] Archives Générales de Médecine, 1872, t. i. pp. 276, 555, 703.

of his communication to the Société de Chirurgie, and concludes with these words: "Finally, I shall have to study, as much as possible, the histological process. Is there here the simple effect of contact, or vicinity? Is there proliferation of the transplanted elements?" During the progress of experimentation, many questions, of course, arose, which have not yet all been answered; but after the adherence of the grafts was accomplished, and epidermis was observed to form around them, Reverdin came to the conclusion that "the epidermis by itself, but still the living epidermis, that of the deep layer, would alone be necessary for the success of the grafting."[1] And again, "the adherence of the graft is, therefore, effected by the epidermis; the welding of the dermis is but secondary and accessory; the part played by the dermis in the properties of the formed islets is, therefore, completely null." But the grafts remain, and are not absorbed; yet, as Poncet[2] expresses the idea, "The cutaneous graft not only is not re-absorbed, but it possesses all the properties of the skin."

The views entertained by Reverdin with regard to the epidermis seemed to him to find confirmation in "a little fact" which was that, in some cases, he found upon the strips of plaster grafts which, put in place the evening previous, had failed to unite, but which, upon being replaced, "took" perfectly.[3] We shall see, further on, that Georges Martin,[4] in his thesis "upon the duration of the vitality of the tissues and of the conditions of adherence of cutaneous restitutions and transplantations," ascertained, through observations of his own, that some separated bits of human skin maintained their vitality, when exposed in free air, for ninety-six hours, and others in a confined space for one hundred and eight hours, at a temperature of nearly zero, C. [32° F.].

Hamilton failed to perceive that, without peduncular attachment, his little flap might adhere and grow; but Reverdin saw this, and so earned his honors. He communicated his discovery to the Société de Chirurgie on the 8th of December, 1869; the commission to which it was referred, consisting of MM. Guyon, Chassaignac, and Desprès, made a report; and Guyon, in whose service the experiments were made, presented the subject verbally, and provoked a discussion hardly favorable to skin grafting. But Verneuil declared himself in favor of the method, which he believed was calculated to render service in many departments of surgery. Gosselin, Guyon, Alphonse Guérin, and Duplay offered encouragement, and extended facilities;[5] and Marc Sée dispelled the bad impressions remaining by presenting, six months afterwards, a patient who bore evidence of the success of the operation,[6] in which Sée had been aided by Reverdin himself.

Grafting now became the fashion; M. Vulpian[7] presented before the Société de Biologie, in the name of M. J. M. Phillipeaux, a case of transplantation of the spur of a young cock of forty days upon the comb of the same animal, in which the spur became incorporated with the skin, formed no adhesion with the cranial bones, but surpassed in length its non-transplanted fellow. Some grafted the skin of the white man upon the negro;[8] or took grafts from moles or parts stained with India ink;[9] or borrowed skin from amputated members;[10] or even supplemented, in the case of a large ulcer after a burn in a little girl, some three hundred grafts from the patient herself,

[1] Loc. cit., p. 707.
[2] Lyon Médical, t. xiv. pp. 293, 294, 1873.
[3] Loc. cit., p. 709.
[4] Georges Martin, Thèse, Paris, 1873.
[5] Archives Gén. de Méd. 1872, t. i. p. 277.
[6] M. Sée, Gazette Hebdom. de Paris, Juillet 20, 1870; J. Ustariz, Sobre los Ingertos en general, etc. Anfiteatro Anat. Español. Madrid, 1877; and E. T. Easley, Am. Med. Weekly, Louisville, Ky., 1876, vol. iv. p. 353.
[7] Comptes rendus des Séances et Mém. de la Soc. de Biologie, t. ii. 5e Série, Année 1870.
[8] G. T. Maxwell, Philad. Med. Times, 1873, p. 37.
[9] J. T. Hodgen, Cell or Skin Grafting. St. Louis Med. and Surg. Journ., 1871.
[10] B. Anger, Sur l'Hétéroplastie. Comptes rendus hebdom. des Séances de l'Acad. des Sciences, t. lxxix. p. 1210. Paris, 1874.

with a score of others derived from a young pig.[1] Animals, also, were made the subjects of experimentation; indeed, some years before 1869, with regard to animal grafting it was proposed to "unite," or "glue together," two animals by their cutaneous envelopes, and even animals of different species.[2] Some, like Reverdin, preferred small grafts; others, as M. Ollier,[3] thought better of larger ones, even reaching the dimensions of eight square centimetres, or, as Donnelly,[4] employed those of a diameter of a quarter of an inch. Savrey, quoted by Georges Martin,[5] asserts that "two Swedes, to give each other a durable remembrancer, exchanged a bit of skin of the inside of the forearm;" but the most remarkable graft ever applied was one of which we find the account in the discourse of Ustariz already referred to. It is as follows:—

"Armaignac says that, in the seventeenth century, there is seen a light glimmering in this direction, quoting a case, related by an ecclesiastic named Kraemoinkel, of a soldier who had lost a large part of the hairy scalp and of the bone beneath it, the surgeon closing this opening with a portion of bone and skin, of the same form and dimensions, taken from a dog which he killed for the purpose. As it appears, the Church being apprised of the matter, there were launched against the poor surgeon all the anathemas and furies of which that institution is capable; and it became necessary for his return into the communion of the faithful that he should practise a new operation upon the unfortunate soldier, ridding him of that unclean spoil of dog which had become strongly consolidated with the adjacent parts, and, as Armaignac facetiously remarks, subjecting him to a treatment more conformable to the Christian character."

The whole matter of skin, or, as Reverdin calls it, epidermic grafting, was liberally treated by that author in the *Archives Générales de Médicine* for the year 1872. His method, exceedingly simple, may be expressed in a few words. Taking usually his little bits from the inner surface of the leg, he rendered the skin tense over the flat surface of the tibia, and introduced the point of a rather large venesection lancet parallel to the bone, and to the depth of a half millimetre; then pushing it forward so that the point should emerge three or four millimetres further on, the little piece was cut loose by the edges of the instrument. "The little wound," he adds, "is the seat of a fine sanguineous dew." "I apply," continues the author, "my lancet, bearing the graft, upon the granulations which I have selected, and slide it upon them with the point of a pin. It is thus in relation with the granulations by its deeper face, and I ascertain, by a motion from side to side, that no part of its edge is rolled up, for it is necessary that it should be completely spread out. This result once obtained, and all my grafts in place, I cover them with strips of diachylon plaster, which are not removed for twenty-four hours." Sometimes the grafts were furnished by the subject himself; at other times they were successfully borrowed from a different person; now they were obtained, as at Guy's Hospital and at St. Bartholomew's, from limbs recently amputated; or, again, they were derived from the cadaver, soon after death, as by M. Prudhomme.[6] One fact, says Reverdin, would be of great importance "if it were perfectly demonstrated." Dobson and Laroyenne[7] found it necessary and advantageous to borrow grafts from young subjects to implant upon aged patients. But, from his own experience, the inventor of the process does not "venture to draw a definitive conclusion" upon this point. We learn also

[1] Thomas F. Raven, British Medical Journal, London, 1877, vol. ii. p. 623.
[2] P. Bert, Exp. et Consid. sur la Greffe Animale. Journal de l'Anat. et de la Physiol. normale et path., t. i. pp. 64, 87. Paris, 1864.
[3] Ollier, Sur les Greffes Cutanées ou Autoplastiques. Bull. de l'Acad. de Médecine, Paris, 1872, pp. 242, 246.
[4] Donnelly, New York Med. Record, 1872, p. 572.
[5] Georges Martin, op. cit. p. 14.
[6] Lancet, May 20, 1871; Thèse de Colrat; Reverdin, loc. cit.
[7] Med. Times and Gazette, Oct. 29, 1870; Colrat, op. cit.; Reverdin, loc. cit.

from Reverdin's memoir that grafts were taken by himself and others from negroes; that little bits derived from different animals could be successfully grafted; and also that Czerny and others had transplanted pieces from the mucous membranes.

We have, so far, traced in brief detail the method of the pioneer himself, and reproduced his views at some length, for the reason that his observations were so exact, and his practice so sure, that those who followed him made but little change in the plans proposed, found few opportunities for new applications of the practice, and emitted not many original views as to the plans of operating, the mode of attachment of the bits of tissue, or the general laws of physiology applicable in the mass of cases, or in particular instances. But real progress was, perhaps, determined by the recognition of the elements upon which proliferation depended, and of the fact that the marginal cicatrix was formed from all the borders of the grafts; although N. C. Dobson[1] had declared, as early as 1870, that the growth of cicatrix was not unlimited, and that no one island exceeded the dimensions of a sixpence. And the same may be said with regard to the conditions necessary to success, for, as all ulcers tend towards or must be brought to the form of the common or typical ulcer in the process of healing,[2] so must all ulcers, for a favorable reception of the grafts, be already covered with willing granulations, or be made to be covered with them. To express the same idea in the words of Reverdin, "the end to be attained when we wish to prepare a wound for grafts, is to obtain [a surface of] granulations as well defined as possible." And it is here of interest to record the fact that, in speaking of the growth of the little islands, as determining the rapidity of cicatrization, Reverdin informs[3] us that the observation of a case of ulcer in which the formation of pellicle advanced from spontaneous "*ilôts*," gave him the first idea of "*la greffe épidermique*."

But rapidity, although promoting a prompt cure, was found to be associated with solidity, and this latter quality with permanency. For a time, says Reverdin, the cicatrix due to the grafts is a little prominent, but eventually becomes depressed "as an umbilicus;" then around the grafts is formed a whiter, thicker, and more solid cicatrix, and one which resists relapses.[4] And although his facts were few, still results seemed to point to the conclusion that "cicatricial retraction and vicious cicatrization" were opposed, rather than favored, by the new process.[5] "I can now conclude," says Reverdin, "(1) That by grafting we may prevent the adhesion (*soudure*) of two neighboring granulating surfaces. (2) That as for retraction, reasoning and certain facts demonstrate that it can be prevented, at least in part, by means of grafts. (3) That the applications [of grafts] made for the cure of certain deformed cicatrices have given good results; these results should be verified by time."

There remains to be briefly noticed Reverdin's view with regard to the part taken by certain elements in the formation of a cicatrix, and to do this I will reproduce his language, premising the quotation with his statement that, "on account of pain and possible accidents, small grafts are preferable."[6] Thus: "The epidermis by itself, but the living epidermis, that of the deep layer, is alone necessary for the success of the graft."[7] "The adherence of the graft is accomplished, then, by the epidermis; the union of the dermis is only secondary and accessory."[8] And finally, the opinion is expressed that we can greatly facilitate the cure of rebellious wounds of which the duration bears no relation to their extent.

[1] Med. Times and Gazette, Oct. 29, 1870, p. 500; Reverdin, loc. cit.
[2] Paget, in Holmes's System of Surgery.
[3] Loc. cit., p. 555. [4] Loc. cit., p. 564. [5] Loc. cit., p. 571.
[6] Loc. cit., p. 711. [7] Loc. cit., p. 707. [8] Loc. cit., p. 708.

A. Poncet, in the previous year, 1871, had reviewed the whole matter, method and all, in a paper entitled "Des greffes dermo-épidermiques, et en particulier des larges lambeaux dermo-épidermiques,"[1] taking up the same texts. In a discussion upon the subject,[2] participated in by Letiévant and others, the former says, speaking of animal grafts, "I call these grafts zoo-epidermic, in opposition to human grafts which I distinguish under the name auto-epidermic or hetero-epidermic, according as the grafts are gathered from the subject grafted or from his neighbors." Then the means employed to secure the grafts are referred to, the lancet of Reverdin, the scissors of Pollock, the cataract-knife of Ollier—all effecting the lifting of the epidermis and of the superficial layer of the dermis. But even with the weight of testimony in its favor, Letiévant felt called upon to appose the remark "that the practice of skin grafting should be rejected as hurtful, and that it led to neglect of the important indications of the treatment of wounds," and at the same time undertook the defence of zoo-epidermic grafts, from the dog for example, because auto-grafts were painful, and caused new wounds in the patient. M. Christôt promptly denied that he had declared grafting to be useless, but did not avow himself a partisan of the process; and with this denial further opposition to skin grafting seems to have ceased.

We have presented with some liberality the views of Reverdin with regard to the process of his inventing, frequently quoting his own words. It is here interesting to compare or contrast the ideas entertained by Poncet with those of the master, following upon the discovery of Reverdin, although antedating in publication the formulized expressions of the latter.

At the end of the discussion just referred to, Poncet[3] took occasion to recommend the practice of Ollier in the employment of large and numerous grafts, stating at the same time that he had failed with epithelial grafts alone; and continuing his discourse he goes on to say that "as to the proliferation of the epithelial elements, it is a simple action of the presence of the mucous layer of the epidermis, determining at times the epithelial transformation of the elements of the embryonal tissue, to which it is united. . . . In the seam of junction of the granulations with the morsel transplanted, the same phenomena are observed as in the union of the margins of a wound by first intention. The extension of the graft has not seemed to us to be owing to a proliferation of the mucous layer. It must act by its presence upon the embryonal elements directly in relation with its margins, and thus determine their epidermic transformation." In the same connection we refer to the opinions already advanced by Reverdin, and we propose to adduce those of Coste, as expressed in a conference upon epidermic grafting held on the 31st of May, 1873, at the École de Médecine.[4] "How," asks the distinguished professor, "is the adhesion brought about? How is proliferation accomplished? That is very simple. The transplanted epidermis determines by its presence, by its contact, the transformation of the embryonal cells of the granulations into epidermic cells. This, according to Reverdin, Colrat, and Poncet (de Lyon), is the most probable, and even the only possible theory."

On the other hand Mr. Bryant gives utterance to a directly opposite doctrine. In notes from the Wards of the Cork Hospital,[5] communicated by Mr. Martin Howard, we find the following: "The question was asked whether the skin graft was an excitor of skin action, or were the cells proliferated? Mr. Bryant declared that the grafts grew, the skin being prolonged from the graft, and that the border also threw out a growth. This he proved in the following ingenious way. He had a white man under his care, suffering from an ulcer on his leg, and on this ulcer he grafted a portion of the skin taken from a negro in the hospital. As the ulcer decreased in size, the piece of black skin increased considerably." However satisfactory this experiment may have been, the observation is at variance with those of Reverdin and of Coste, the latter of whom expressly declares[6] that "grafts borrowed or obtained from a negro and implanted upon a white person, rapidly lose color and bleach out entirely, from the effect of the progressive absorption of pigment. "I saw," says this author, "a remarkable example of

[1] Lyon Médical, t. viii. p. 494, 1871. [2] Ibid., p. 520. [3] Lyon Méd., p. 564.
[4] Marseille Médical, 10e année, No. 7, Juillet, 1873.
[5] Dublin Journ. of Med. Science, vol. lxi. p. 388. [6] Loc. cit., p. 398.

this, a few months ago, at the Hôtel Dieu, in Paris. Besides which I note the rarity of pigment in cicatricial epidermis." M. Coste finds it necessary to preface his remarks with the observation that "in spite of the identity of terms, the animal graft bears no resemblance, either in its course or in its definitive evolution, to the vegetable graft; a radical difference separates the two. What," asks the professor, "is a vegetable graft? It is an individual, or a part of an individual, transplanted upon another individual, which in some way serves as a soil for it. In this soil it lives as a parasite, the transported individual develops and lives a life which is its own, meanwhile preserving its autonomy, its individuality. It is quite different, in the double point of view of theory and practice, with regard to the animal graft. This, borrowed from the individual himself or from another, has essentially for its object the filling up of a loss of substance. The borrowed part and that to which it is united, after reciprocal modifications and influences, coalesce, the one with the other; they end by becoming confounded, by being identical, by living a common life. There is, therefore, no analogy between the animal graft and the vegetable graft; these two grafts resemble each other in name only." We will not follow Coste further, but merely state that he reviews the experiments of Bert, especially the "*greffe Siamoise*" of that observer, the "*rat sur rat*," which tests his own views upon the same subject.

Again, in 1872, M. Reverdin insisted upon the manner of adherence of the grafts, and of their effect on granulating surfaces—for he laid his grafts upon the surface—and declared[1] that he saw grafts from the negro, or black cat, lose color and become altogether white. And in a note upon epidermic grafting, presented by M. Claude Bernard to the Academy of Sciences, at the meeting of November 27, of the same year, Reverdin says: "There results from this histological examination (1) that the adherence of the graft is effected, in the first place by the epidermis, and only secondarily by the dermis; (2) that the epidermis acts by action of contact (catabiotic action, Gubler), in determining the transformation of embryonal elements into epidermis." In the same volume, page 326, may be found a note of M. Ollier, presented by M. Claude Bernard at the meeting of March 18, containing the following, bearing upon the subject before us, namely, the aim and action of the transplanted or transported germs: "As for myself, in transporting large cutaneous morsels I seek to reduce, as much as possible, the natural *épidermization* of the granulations. My aim is to change, upon a more or less extensive surface of the wound, the process of repair. I replace the epithelial layer of new formation with a cutaneous, fleshy, thick layer, stable in its fundamental elements, and destined to fill the rôle of a true skin. It is, therefore, an autoplasty which I perform."

While not attempting a complete history of skin grafting, I have nevertheless followed the idea from mind to mind, and developed, although not at great length, the opinions entertained by the originator himself, as well as by those of his countrymen who stood, so to speak, around him, concerning the part performed by the germs transported and transplanted. The preponderance of testimony seems to weigh in favor of the view that the epithelial germs grow in or upon their new soil, but that a more remarkable phenomenon, to be observed after the transfer, is to be found in the influence which they exert in determining by their presence and contact the transformation of the embryonal cells of the granulations into epidermic cells. And this power does not appear to be limited to the immediate neighborhood of the grafts, but seems to be communicated to the sluggish borders of the wound or ulcer.

Reverdin presented his first case and announced his discovery on the 8th of December, 1869. In England, the value of "epithelial grafting" was at once appreciated, and as early as May, 1870, Mr. G. D. Pollock, of London, had put Reverdin's method in practice, and had tested it in four cases, which, with a number of others, were made the subject of a paper entitled "Cases of Skin grafting and Skin Transplantation," read on November 11, 1870, and

[1] Bulletin de Thérapeutique, t. lxxxiii. p. 71, 1872.

published in the Transactions of the Clinical Society of London, for the year 1871. At first he made a slight incision in the granulations, and imbedded the piece of skin; but afterwards he followed Reverdin closely, laying the graft on the granulations, or surface of the ulcer. He found no difference in the results; but he ascertained it to be essential that the patient should be in good health—a condition which appeared to lie at the foundation of success. With regard to the process of cicatrization itself, I prefer to adduce the words of the author, for it will be observed that, while agreeing to some extent with Bryant, already quoted, in his explanation of the phenomena occurring after, or induced by, grafting, he differs altogether from Reverdin, Coste, Poncet, and other French authorities, and, in differing, presents some new features in the case.

When, as Pollock expresses himself, a graft is successful, there appears a fine, thin, delicate membrane, and in this membrane may be seen a beautiful network of red vessels. Shortly the membrane becomes white, and the vessels disappear. "The membrane is, as far as I can judge, the deeper layer of epithelial cells which possessed the greatest amount of vitality and youth." And, he adds further on, the wave of new pellicle stimulates the margin of the original ulcer, and induces cicatrization. Mr. Pollock's first case was that of a child of eight years, who, her dress taking fire, was burned in both thighs. The left had healed at the time of her admission into St. George's Hospital, but the right thigh presented an ulcer extending from above the trochanter down to the outer surface of the knee. On the 5th of May, the grafting was done, and on the 26th of November, of the same year, the healing was complete. In the second case there were two ulcers; in the third, a chronic ulcer of the right leg; the fourth was one of ulcer over the tibia, from a kick; the fifth one of chronic ulcer of the leg; the sixth, a case of large sore on the chest, from a burn; the seventh, eighth, ninth, eleventh, twelfth, and fourteenth, cases of ulcer of the leg; the tenth, one of scrofulous ulcer of the forearm; the thirteenth, one of contraction after a burn, in which, after dividing the cicatricial bands, the gap was grafted, no success following the operation; and the fifteenth and sixteenth, cases of syphilitic ulcer, in both of which the process proved a failure.

The practice of skin grafting soon found favor in England, in spite of misgivings more or less distinctly expressed, and cases were presented to various medical societies. Among the many, we may refer to the cases of Mr. Pearse,[1] in his account of which the author advocated the employment of small pieces, and making a wide gap; and to that of Mr. Raven,[2] who supplemented insufficient grafts from a little girl, with "zoö-epidermical" grafts from a young pig.

The method was adopted in Germany, in which country Dieffenbach had given such development to plastic surgery; into Italy it speedily found its way; in Spain, and other European countries, it became the accepted innovation, as, for example, in Constantinople, in which city Zebrowski published, in 1873,[3] an essay upon skin grafting—"Sur la greffe épidermique"—basing it on observations made upon eight successful cases. In fact, to use the language of Martin Howard,[4] in his communication already referred to, "In the journals will the work of the grafters be found;" an evidence of the lively zeal with which the profession tested and approved of the practice.

It will presently be seen that skin grafting became immediately active in America, reaching almost synchronously the United States, Canada, and Mexico; but we prefer, in order to preserve the autonomy of the subject, to revert to the two questions which arose in the country of its origination, and which have an important bearing both upon the theory and the practice of

[1] Practitioner, vol. viii. p. 36–39. London, 1872.
[2] Loc. cit., 1877.
[3] Gaz. méd. d'Orient, t. xvi. pp. 136, 137.
[4] Loc. cit., p. 386.

the operation. The first of these refers to the *persistence of vitality* in the grafts; and the second to the size of the particles or pieces translated; questions which, as may be supposed, commanded the attention, not of French observers only, but also of those of other countries, without excluding the members of the medical profession in the United States. Not that these questions were absolutely disposed of in France, but that they were presented in a very formal manner in several papers of note.

The first of these, by Paul Bert, antedated skin grafting, so called, and had for its title "Experiments and reflexions upon animal grafting,"[1] and entertained the proposition "of the preservation of vital properties in parts separated from the body;" and declared that "transfusion of blood, animal grafting, restoration, constitute but one single and immense order of facts, which are properly studied simultaneously, and which might be comprehended under one common formula." Then follow his divisions, (1) animal graft; (2) "marcotte," by slips or shoots; and (3), grafting by approximation of animals of different species. Under *marcotte*, Bert ranges the "Indian method, in which the flap is never for a moment separated from the body." It will be observed that Bert treats of anaplasty and autoplasty, and the same may almost be said of Ollier,[2] of Lyons, who, at a later period, discussed the whole subject of animal grafts, giving preference to larger pieces instead of the minute morsels recommended by Reverdin, approaching the boldness, but not quite equalling the venture, of Hamilton, of New York. Paul Bert's remarkable experiments in animal grafting[3] gave as results the following; of less value from the fact of the adhesion of the tails of rats, than from the length of time which had elapsed since their amputation before they were applied to a stump. Thus tails of rats, separated from the animal for $3\frac{1}{2}$ hours, adhered when grafted, and so did others after a lapse of $7\frac{1}{2}$, 16, 26, 48, 62, 64, and 72 hours, although failure ensued in other cases. And Ollier[4] adduced instances of periosteal flaps 24 hours old, obtained from a rabbit, which adhered when applied to another animal of the same species.

Georges Martin, in his Thesis already referred to, upon the duration of the vitality of tissues, etc., brings together 343 grafting operations, which form the object of 60 personal observations, and, in detailing these, records very surprising experiments and their results; and he quotes Baronio, Gohier, Wiesmann, Dieffenbach and others, and their variable success. But the most worthy of attention are his original experiments and observations, as to the limits of vitality, with cutaneous and dermo-epidermic grafts in the human subject. It would appear that none of his grafts lived and were effective after 108 hours' exposure "in free air" at a temperature of nearly zero, C. [32° F.], but that when kept in tubes, or confined air, under the same circumstances, the grafts were successful. Another experiment, the temperature being nearly at zero, C., was successful after 96 hours, the morsel having been preserved in free air; in another, the temperature being 6° C. [42°.8 F.], the limits were 82 and 96 hours, under the respective conditions of free and confined air; when the temperature was 12° C. [53°.6 F.] they were 72 and 84 hours; when 15° C. [59° F.] the figures were 60 and 72; when 20° C. [68° F.], they were 36 and 36; and, finally, a last experiment, at 28° C. [82.°4 F.], showed the limits of vitality to be 6 hours and 7 hours, in free and in confined air respectively.

M. Martin laments that we have no medicament capable of prolonging cellular life, but he asks the question, whether certain alkaline solutions may not afford the means. In this connection he quotes M. Caliste, as having proved that muscular irritability continues for a long time in a weak solution of potassa, while distilled water destroys it rapidly, and M. Pélikan, who saw frogs' muscles, plunged in these solutions, remain intact after fourteen days. Finally, M. Brown-Séquard noticed contractility of the iris for sixteen days, and accounted for the phenomenon by the residence of the membrane in the alkaline media of the eye. Besides the conditions referred to as favoring adhe-

[1] Journal de l'Anat. et de la Physiol. normale et pathol. de l'homme et des animaux, t. i. pp. 69–87. Paris, 1864.

[2] Bullet. de l'Acad. de Médecine, t. i. 2e série, pp. 242–246. Paris, 1872. "Sur les greffes cutanées ou autoplastiques."

[3] These, 1863. See also Coste, Marseille Médical, 1873.

[4] Traité sur la régéneration des os, t. i. p. 417.

sion of the grafts, or "success" as M. Martin calls it, he declares that "longevity is inversely as the mass." Of course, the conditions of the persistence of the life of the graft receive careful attention, and temperature, hygrometrical state, and volume, are referred to as the agents which chiefly influence its duration. Cold, says M. Ollier, favors the success of transplantation; and "elevation of temperature," in the language of Bert, "is one cause of a shorter duration of vitality." Moisture hurries decomposition; and smaller masses live longer than the larger. And, finally, the bit of living tissue to be preserved must be maintained at a low temperature, and in a vessel hermetically closed. Among the conclusions reached by M. Martin, we may give prominence to the following, which bears upon large and small grafting alike; "a separated part preserves its vitality for several days, during which it is apt to contract adherence." "The surgeon, therefore, will always be called in time to replace an organ; besides, he may employ for the reconstruction of a separated organ a bit of tissue some time removed." So that, in preparation for a plastic operation, "tissues may be collected in an amphitheatre immediately or soon after death." It is almost needless to add that the condition of the part receiving the graft, as well as that of the graft itself, must be suitable; for, in order to procure adhesion, the mutual concurrence of the plasmatic cells of the piece transported, and of the breach, is indispensable.

From the foregoing experiments we are led to believe that parts separated from the body retain their vitality for a very considerable time; and, granting that the experiments could be repeated, the surgeon need find no difficulty in appropriating, as has been done, flaps from amputated members, or even borrowing particles or bits of tissue from the cadaver.

As we have already remarked, skin grafting speedily had its claims acknowledged in America; indeed Bernutti[1] refers to the statement of Spantigati as to the communications of Reverdin and of Frank Hamilton, of New York, having been sent in December, 1869, to the Société de Chirurgie, of Paris, but adds that there is in the Bulletins of that Society for 1869, no record of Hamilton, whom Spantigati makes co-author with Reverdin. One of the earliest notices of skin grafting by a writer on this continent, was contained in a paper, published Dec. 12, 1870, by Sr. D. Luis Muñoz, of Mexico,[2] in which the subject was carefully presented; and this was followed by another, accompanied with four cases, by J. M. Bandera, which appeared the following year, in the same Journal. In the same year, 1871, Prof. J. T. Hodgen contributed to the St. Louis Medical and Surgical Journal[3] articles upon "Cell or Skin Grafting," giving cases, and explaining the methods of procuring grafts employed by himself. These were three in number: (1) By snipping off bits of human skin and epithelial layer; (2) by scratching off scales of epithelium; and (3) by removing sheets of detached portions of epithelium. And he grafted also from parts stained with India ink, and from moles. Hodgen was successful in his grafting; but it is remarkable that he obtained results with pigmentary grafting quite at variance with those of Reverdin, Coste, and others in France, although he found them in correspondence with those of Bryant, already referred to in this article. The American author says that when cells of the deep layer of the epithelium are used, the pigment also grows with the growth of the graft, but that when old dry scales are grafted, no pigmentary deposit takes place. It is curious to contrast with the experience of Hodgen that of Maxwell,[4] who, to fill a gap produced in the face by a gunshot wound, resorted to an anaplastic operation, engrafting the skin of a white man upon a negro patient, with

[1] Giorn. della Reale Accad. di Medicina di Torino, t. xxxvii. pp. 35–55, 1874.
[2] Gaceta Med. Mejico, 1870.
[3] St. Louis Med. and Surg. Journal, vol. viii. N. S., p. 289, 1871.
[4] Phila. Med. Times, vol. iv. p. 37, 1873.

the consequence of finding, after three months, that the white skin had lost its distinguishing character, "and that the whole surface of the wound was of uniform blackness." Many experiments were subsequently made, from time to time, in colored skin grafting, but we need refer only to those of J. H. W. Meyer, who reported two cases in 1877.[1]

Skin grafting was now practised in all parts of North America. In Canada, in 1871, in the proceedings of the Medico-Chirurgical Society, of Montreal, we find that Dr. W. H. Hingston evoked discussion upon a paper on skin grafting, accompanied with cases.[2] In Baltimore, Prof. J. J. Chisolm[3] practised skin grafting publicly, and advocated the employment of grafts obtained from the deeper parts; in California, Prof. H. W. Toland recorded a case of skin grafting practised by him in 1873;[4] and in 1874, Prof. D. Hayes Agnew,[5] of Philadelphia, published cases and remarks upon ulcers and skin grafting, reported favorably upon the process, and proposed to supply skin from a portion of the body corresponding to the diseased part, as promising more success.

It were invidious, almost, to withhold the names of the surgeons who made early application of the new process of inducing cicatrization, but the limits of this article forbid the enumeration. We may, however, refer to Dr. Howard's[6] investigation of "muscle grafting," which he believed to disprove the "epithelium theory;" to Dr. M. Donnelly's[7] paper, with cases, on skin grafting as practised in St. Vincent's Hospital; to that of Dr. W. F. Cheney,[8] with cases, in 1872; to the paper aud cases of Dr. E. L. Wemple[9] in 1873; to the contribution of Dr. J. W. Trader,[10] in the Medical Archives of St. Louis, relating to a railroad injury in which, after sloughing of the crushed foot, skin grafting was happily resorted to; to the Bellevue Hospital report,[11] in 1873, of the method of setting grafts, referring to the setting of two thousand grafts; to a case of Dr. B. M. Cromwell,[12] with comments, reported in 1875; and finally to Prof. S. G. Maclean's successful treatment of a large ulcer by simple measures and skin grafting.

Before concluding this article, I purpose to briefly review the opinions entertained with regard to the preferable size of the grafts, and begin by stating, on his own authority, that Reverdin always adhered to the small grafts with which he inaugurated his system, and that Mr. Pollock was, in the main, likewise minded. Nevertheless, we find M. Ollier,[13] in 1872, saying that, instead of grafts, little morsels of two, three, or four millimetres square are preferably used, "as is practised by M. Reverdin." And further on, Ollier adduces his favorable experiences with grafts of large size, of four, six, or eight square centimetres, involving the entire dermis, and constituting "a veritable autoplasty;" and expatiates upon the necessity of immobility in the parts submitted to operation, adding that this is best secured by a silicated apparatus. At first he employed epidermic grafts, then dermo-epidermic grafts of one or two centimetres' extent, and finally grafts of skin and cellular tissue; all in one patient, to procure cicatrization after a large burn. He observed, how-

[1] Chicago Med. Journal and Examiner, vol. xxxiv. p. 320, 1877.
[2] Canada Med. Journal, vol. vii. p. 495. Montreal, 1871.
[3] Richmond and Louisville Med. Journal, vol. x. p. 353, 1870.
[4] Western Lancet, 1874.
[5] Med. and Surgical Reporter, Nov. 1874.
[6] New York Med. Journal, Sept. 1871.
[7] New York Med. Record, vol. vii. p. 572, 1872.
[8] Trans. Med. Society of California, 1872, pp. 106, 108.
[9] Pacific Med. and Surgical Journal, vol. vii. p. 381, 1873–4.
[10] Med. Archives, vol. vi. p. 257, 1871.
[11] New York Med. Record, vol. viii. p. 538, 1873.
[12] Atlanta Med. and Surgical Journal, vol. xiii. p. 641, 1875–6.
[13] Bullet. de l'Acad. de Méd. Paris, 1872. 2e serie, pp. 244, 246.

ever, that after four, five, or six days the epidermis fell away, and left the graft bare as if it had been blistered; and concluded, from what had occurred, that "perhaps grafts, called *epidermic*, succeed only when containing a lamella of *dermis*." And that these procedures were successful, may be inferred from the fact that, in 1873, Poncet gave in the *Lyon Médical*[1] an account of the "presentation of a patient bearing autoplastic cutaneous grafts introduced a year before by M. Ollier." In America also, in 1872, Dr. M. Donnelly, in a paper already referred to, advocated the use of grafts as large as a quarter of an inch, claiming such to be superior to smaller ones; and declared that he regarded the source of supply as indifferent, except that the graft should be taken from a point of least motion, as the insertion of the deltoid.

In conclusion, we may summarize what is known as to skin grafting as follows:—

I. It affords an admirable means of accelerating and facilitating cicatrization.

II. The pellicle produced by its aid is less prone to contraction, and contracts less than an ordinary cicatrix.

III. The deeper layer of the epidermic elements are the chief factors of growth.

IV. The growing cicatrix is formed at the expense of the embryonal cells of the granulating surface, stimulated into activity by the presence of the living cells of the graft.

V. This stimulus, first showing energy in and around central islands of new growth, induces similar activity at the hitherto dormant margin of the ulcer.

VI. Grafts may retain vitality and be effective long after separation from the body.

VII. Small grafts, of the size of millet seeds, for example, are, in general, preferable to larger ones; although larger grafts, as of one-fourth inch square (Donnelly), or even eight square centimetres (Ollier), have had their advocates and successes.

VIII. Grafts should be obtained from the patient himself, if possible, but in all cases the danger of specific inoculation ought to be present in the mind of the surgeon who borrows grafts from one subject for application upon another, or who practises heteroplasty.

IX. Grafts furnished by the aged are less disposed to adhere than those procured from the young, and oftentimes fail entirely.

X. Grafts obtained from one race of men may be successfully used on individuals of another race; and animal grafts may be transplanted upon human beings, adhere, and provoke cicatrization.

XI. Foul surfaces, or those of persons in bad health, will refuse to accept good grafts; but with improvement or establishment of the health of the individual bearing an ulcer, and the appearance of healthy granulations, a favorable result of skin grafting may be anticipated.

XII. Finally, the great benefits accruing from successful skin grafting far outweigh its drawbacks, which are the pain of the operation, and, unless amputated limbs be utilized, the consecutive pain in the parts yielding the grafts, whether, of course, these be autoplastic or heteroplastic.

NOTE.—The author desires to express his acknowledgements to Surgeon J. S. Billings, U. S. A., for his personal kindness in the matter of collecting authorities, and through him to the Library of the Surgeon-General's Office, for the invaluable aid which it has afforded.

[1] Lyon Médical, t. xiv. p. 293, 1873.

AMPUTATIONS.

BY

JOHN ASHHURST, Jr., M.D.,

PROFESSOR OF CLINICAL SURGERY IN THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA.

The word Amputation, from the Latin *am-* or *ambi-* (Greek ἀμφί), signifying "around," or "round-about," and *puto*, from the root *pu* (to cleanse) signifying to "clean" or "cleanse," and particularly to "trim" or "prune" trees or vines, from its etymological meaning might properly be applied to any operation the object of which was to remove an offending part from the rest of the body, and thus might be made to include such diverse procedures as the removal of tumors, the excision of joints, and the extraction of cataract, as well as the dismemberments, partial or complete, to which it is now habitually limited. Indeed, it was not uncommon, a few years ago, for surgeons to refer to the operation for removal of the female breast, as an amputation of that part, and we still speak of amputations of the penis and of the cervix uteri; but, with these exceptions, the term is now confined to operations for removing the whole or part of one of the limbs, and, when we read or speak of "an amputation," we understand that the taking away of a part or the whole of either the upper or the lower extremity is referred to, and that the operation has, as far as it has gone, been a *total removal*, sparing nothing beyond the line of section.

Amputation, the "last resource of surgery," as Velpeau called it, is often spoken of by the public, and even by some unthinking physicians, as the *opprobrium* of our art; and it is said, very justly, that to have saved one limb is more credit to the surgeon than to have removed, no matter how skilfully, a hundred. It is true that, in a certain sense, the advice to a patient to have a limb amputated, must be regarded as a confession of failure—failure, that is, to be able to effect a cure by other modes of treatment; but apart from those cases of supreme urgency in which the victim of disease or injury is called upon to choose between mutilation and certain death—when, as Velpeau significantly remarks, he will probably choose rather to *live with three limbs* than to *die with four*—there may be many circumstances under which the surgeon will feel justified in recommending, and the patient will not hesitate in accepting, an amputation, which, though not essential for the preservation of his life, may afford the only reasonable prospect of placing the patient in a condition such as to render that life either agreeable to himself or useful to others. And it may be observed that, while on the one hand the improvements in modern surgery have removed from the field of amputation many cases in which the operation would formerly have been considered imperative, yet on the other hand, since the introduction of surgical anæsthesia and of improved methods of treating wounds, the operation of amputation itself is a much less dreadful one than it was in the early part of the present century, and may therefore be properly resorted to in many cases which would formerly have been abandoned as hopeless, and left with-

out any treatment at all. Indeed, so far from the operation of amputation deserving to be spoken of in any opprobrious terms, or to be regarded as a brutal procedure, it may well be called, as it was by some of the older writers, "*the humane operation;*" and, abused as it may have been in some instances, it is doubtful if any other surgical manipulation has upon the whole afforded as much relief from suffering, or saved as many lives.

Amputations have been variously classified by authors, but the division commonly employed at the present day, and that which has most practical value, is into amputations in the *continuity* of a limb, or through the bones of which it is constituted, and those in the *contiguity*, or through the joints the latter are also called *exarticulations*, or *disarticulations*.

History of Amputation.

The operation of amputation was known to the ancients, but was ordinarily limited to the severing of gangrenous portions of the limbs by incisions through the parts already dead. Hippocrates, who lived four hundred years before the Christian era, in his treatise on the *Joints*, speaks of gangrene resulting from occlusion of the bloodvessels, or following fractures, and directs that in the latter cases the mortified parts should be allowed to drop off of themselves, as, the bones having already given way, the separation of the dead from the living parts will occur quickly; when, however, the bones are entire, the portion which is below the line of blackness is to be removed at an articulation, care being taken not to wound any part which still maintains its vitality, lest, if the operation should cause pain, the patient might faint away or even die in consequence.[1] Celsus, however, who flourished in the reigns of Augustus and Tiberius Cæsar, directed that when a gangrenous limb was to be cut off, the flesh should be divided with a knife between the living and dead parts, down to the bone—taking care to avoid the articulation, and rather taking away some of the healthy tissue than leaving any part of that which was diseased; when the bone was reached, the healthy flesh was to be pushed back from it, and cut around the bone, so that a part of the latter should be left bare; this was next to be divided with a small saw, as close as possible to the adherent flesh, the sawn edge of the bone smoothed or polished, and the skin drawn down again over it.[2] It is not improbable that Celsus understood the use of the ligature in amputations, as he certainly did in cases of vessels wounded in their continuity, though he gives no special directions for the restraint of hemorrhage either during or after the operation. It will be observed that in recommending the incision through living tissues, and the section of the bone at a higher point than that at which the soft parts were to be cut, this writer was far in advance of his contemporaries, as indeed of many of his successors, and in the latter particular actually anticipated one of the most important improvements in the manual procedure which has been introduced, or rather re-introduced, in comparatively modern times. Galen (A. D. 131–200) repeats the advice of Hippocrates that no living part should be touched in an amputation, and gives as a reason for preferring operations through the joints, that the work will be done more quickly than if the bones have to be divided.[3]

The first attempt to prevent hemorrhage *during* an amputation appears to have been made by Archigenes (A. D. 81–117), who directed that the vessels

[1] Hippocratis opera omnia, edit. cur. C. G. Kuhn, t. iii. p. 247.
[2] A. C. Celsi Medicinæ lib. vii. cap. xxxiii. Edit. L. Targæ, p. 417.
[3] Claudii Galeni opera omnia, edit. cur. C. G. Kuhn, t. xviii. pars i. p. 718.

supplying the limb should be tied or sewed as a preliminary measure, or that, in some cases, a fillet should be applied around the limb as a whole;[1] when the operation was terminated, this band was to be removed, and a hot iron applied if there was much bleeding. Heliodorus, who practised at Rome about the same time as Archigenes, advised that an incision should first be made on the side of the limb which was least muscular; that the bone should be sawn through next; and that the section of the thickest part of the limb should be kept until the last.[2] Paulus Ægineta, who is supposed to have lived during the seventh century of our era, also recommended, on the authority of Leonides, that the section of the part containing the principal vessels should not be made until after the division of the bone, and added that the soft parts should be protected from contact of the saw by means of a linen rag (*retractor*).[3]

Turning to the Arabian writers on surgery, we find that Avicenna or Ibn-sina (A. D. 980–1037) mentions the operation of amputation in connection with the general subject of sawing bones, but gives no special directions as to its performance.[4] Rhases, or Razes, who flourished about a century earlier, refers to the use of a retractor, and in the fifteenth book of his *Liber Continens*, or Comprehensive Book (a kind of common-place book treating of all subjects relating to medicine), recommends extraction of the whole bone in cases of caries or "spina ventosa.[5] Haly Abbas (Alee-Ibnool-Abbas), who died at the end of the tenth century, also recommends the use of a retractor, and gives advice as to the mode of making the incision for amputation, almost identical with that of Paulus Ægineta.[6] Albucasis (Aboo-l-Kasim), who lived about a century later than Avicenna, gives similar directions, but adds nothing new to the subject.[7] The surgical writers of the Middle Ages, such as Theodoric, Bishop of Cervia[8] (died A. D. 1298), Gui de Chauliac, who was the papal physician between 1340 and 1370,[9] and Leonardus Bertapalia, who appears to have flourished in the early part of the fourteenth century,[10] commonly contented themselves with copying or paraphrasing the teachings of their predecessors. I may conclude this brief sketch of the ancient doctrines of amputation by quoting from a sixteenth century translation of Giovanni di Vigo, who lived about A. D. 1510, the following description of the operation in cases of gangrene: it will be observed that while he mentions the cloth to cover the soft parts, he does not speak of using it as a retractor. The passage is also interesting as containing one of the early references to the induction of anæsthesia by inhalation.

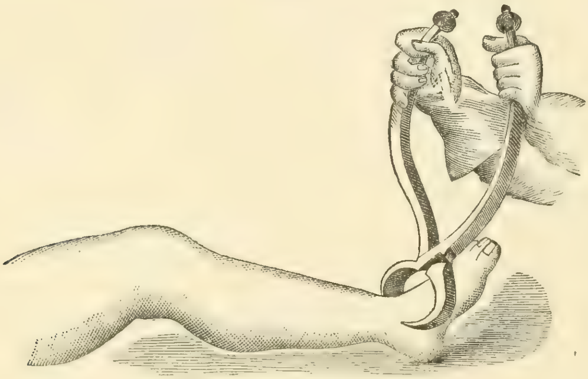
"The manner to cut the corrupt member is this: First, ye must prove with a provet [probe] howe the mortification of the member goeth, and afterwarde yee must cut the member circle wise, in the fleshie and musculous part, and ye must dissever somewhat the flesh from the bone in the over part of the member. And afterward cutte the rotten flesh from the bone by peece meale, and cover the borders with warm cloutes, that they bee not hurt by the ayre. Then ye must compasse about the over parte with your handes, and reduce the flesh circle wise, and sawe the bone as highe as yee canne,

[1] Archigenis de amputandis partibus, apud Oribasii lib. de luxat.; Græcorum chirurgici libri, etc. e collect. Nicetæ, curâ Ant. Cocchii. Florent., 1754, p. 154.
[2] Heliodori de extremis membris abscindendis. Ibid. p. 156.
[3] Pauli Æginetæ Medici Optimi lib. vi. cap. lxxxiv. Edit. princeps. Venetiis, in ædibus Aldi, etc., 1528, fol. 95.
[4] Canonis lib. iv. fen 4, tract. 4, cap. 12. Edit. Cortæi et al. t. ii. p. 172. Venetiis, apud Juntas, 1595.
[5] Haller, Bibiliotheca chirurgica, t. ii. p. 130.
[6] Haly Filius Abbas. Liber totius medicine necessaria continens, etc., Pract. lib. ix. cap. lxv. Lugdun., 1523, fol. 283.
[7] De chirurgia, lib. ii. sect. lxxxvii. Edit. cur. J. Channing, Oxon, 1778, t. ii. p. 419.
[8] Chirurgia, lib. iii. cap. x.
[9] Chirurgia, tract. vi. doct. i. cap. viii.
[10] Tract. de ossibus, cap. ii.

with a Sawe of sharpe teeth. Which done, ye must cauterise the cutte place, unto the whole parte, and afterwarde ye must cauterise the bone, and then cure the Wounde as other burned Woundes be cured. And because that some command to attoine [anoint?] the member before incision, by application of a medicine wherein Opium entereth, or by the smelling of a Spunge wherein Opium is, that the whole bodie may bee brought a sleepe. Yee shall understand (the reverence saved) they enterprise a daungerous businesse, for this disease sometimes chaunceth of a medicine made with Opium, as writers affirme. Neverthelesse the member may be bound afore incision, in the upper part, because of y[e] course of y[e] bloud."[1]

Although, as has been seen, Celsus clearly indicated the importance of dividing the bone at a higher level than the soft parts, his teaching in this respect was soon forgotten, and we find, until comparatively recent times, surgeons of authority recommending that the whole limb should be severed at one stroke. Thus Leonard Botal, of Asti in Piedmont, a military surgeon of the sixteenth century, devised an instrument like powerful shears,[2] by which an amputation could be effected by a single blow—an instrument denounced by Jules Cloquet[3] as more worthy to have been invented by a butcher than by a surgeon—and Purmannus, of Brandenburg and afterwards of Breslau, writing more than a hundred years later, speaks of having seen amputation performed in a similar manner. Indeed in the works of Scultetus,[4] and even of Heister[5] (whose volumes formed the most popular surgical text-book of the last century), may be found illustrations of the severing of parts of the hand or foot with powerful forceps or with chisel and mallet. (Figs. 99, 100.)

Fig. 99.



Amputation of a foot with cutting forceps. (After Scultetus.)

The use of the *ligature*, in amputations,[6] was first clearly taught by the illustrious Ambroise Paré (A. D. 1509–1590), in the middle of the sixteenth

[1] The whole worke of that famous chirurgion Maister John Vigo: Newly corrected, by men skilfull in that Arte. The fourth booke of Ulcers, Chap. 7. At London. Printed by Thomas East, 1586, fol. 252.

[2] Dionis, Cours d'operations de chirurgie, p. 756. Paris, 1740.

[3] Dictionnaire de médecine, edit. 1821, tome ii. p. 240.

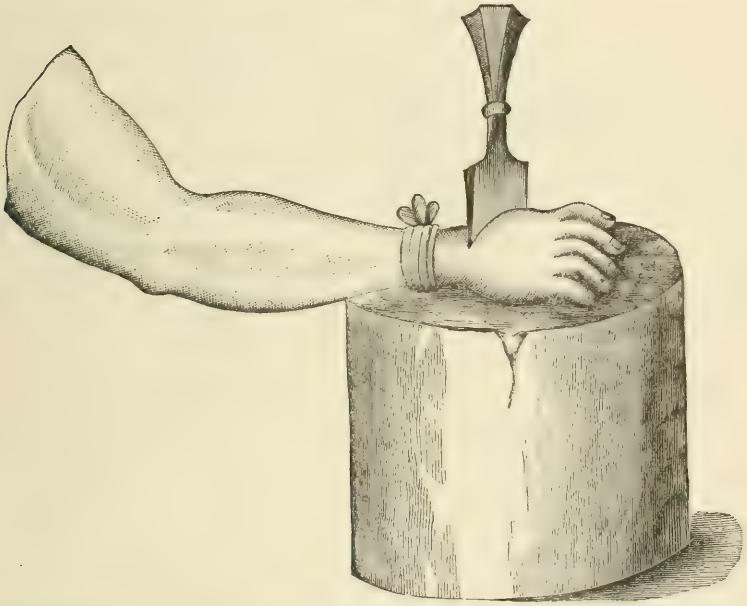
[4] Armamentarium chirurgicum. Tab. xxvii. xxviii. pag. 64, 68. Amst. 1662.

[5] Institut. chirurgicæ, P. ii. sect. i. cap. xxxiii. (tab. xii. fig. 17). Amst. 1739, t. i. pag. 491.

[6] The use of the ligature for vessels wounded in their continuity had been familiar to surgical writers from the time of Celsus, and was particularly referred to by Lanfranc, an Italian surgeon who removed to Paris A. D. 1295 (Ars completa totius chirurgiæ. Tract. i. doct. iii. cap. ix.), by Gui de Chauliac (Chirurgia. Tract. iii. doct. i. cap. iii.) and his follower and commentator Jean Tagault (Institut. chirurg. lib. ii. cap. xii.), by Vigo (Op. cit. fol. 135), and by Marianus Sanctus (Compend Chirurgiæ. Tract. de ulceribus. De Chirurgia Scriptores, etc. [ed. Conrad Gesner], Tiguri, 1555, fol. 161).

century,[1] yet so little was the merit of his teaching recognized that Fabricius of Acquapendente (A. D. 1537–1619)[2] returned to the old Hippocratic doctrine of cutting through dead parts only, while Fabricius Hildanus (A. D. 1560–1634)[3] employed a red-hot knife to sear the vessels as they were cut,

Fig. 100.



Amputation with chisel and mallet. (After Scultetus. The original has been closely followed, even to the extent of giving the patient five fingers and no thumb.)

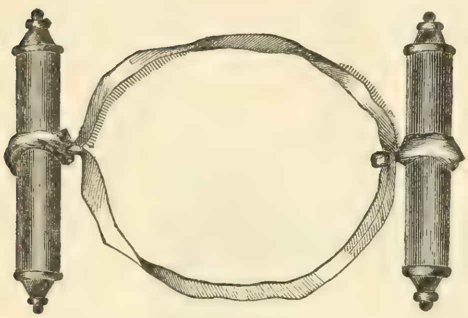
thinking this safer and more expeditious than the application of ligatures, and even Wiseman, the "father of English surgery" (*circa* 1676), though describing Paré's invention, preferred the use of a "royal styptic" or the actual cautery.[4] Peter Lowe,[5] who died in 1612, thought the ligature "reasonable sure, providing it be quickly done;" but Cooke, of Warwick[6] (*circa* 1675), refers to Paré for a description of the method of "stitching" the vessels, and adds that it "is almost wholly rejected;" while the famous quack Salmon (who died in 1700)[7] does not apparently think it even worthy of mention.

Next to the introduction of the ligature, the most important improvement in the operation of amputation was the invention of the *tourniquet* or "*gripe-stick*," as it was called by the English translator of Le Clerc.[8] In its original form, this instrument, which was also known as the *garrot* or *Spanish windlass*, seems to have been devised about the same time (1674) by Morel, a French military surgeon, during the seige of Besançon,[9] and by Young, of

[1] Œuvres complètes, éd. par J. F. Malgaigne. Tome ii. p. 224.
[2] De chirurgicis operationibus, cap. xcvi. Opera chirurgica, Lugd. Bat., 1723, pag. 628.
[3] Tract. de gangræna et sphacelo, cap. xix. Opera, Francofurt. ad Mœn., 1682, pag. 813.
[4] Appendix to Treatise on Gunshot Wounds, chap. ii. Eight Chirurgical Treatises. Sixth edition, vol. ii. p. 225.
[5] A Discourse of the Whole Art of Chirurgerie. Third edition. London, 1634. Book IIII., chap. 7, page 93.
[6] Mellificium chirurgiæ: or the Marrow of Chirurgery. Fourth edition. London, 1685. Part IV. Sect. II., page 203.
[7] Ars chirurgica. London, 1698, Book I. chap. xxxii. (vol. i. p. 92).
[8] The Compleat Surgeon. Fifth edition. London, 1714, page 287.
[9] Dictionnaire des sciences médicales, tome lv. p. 369.

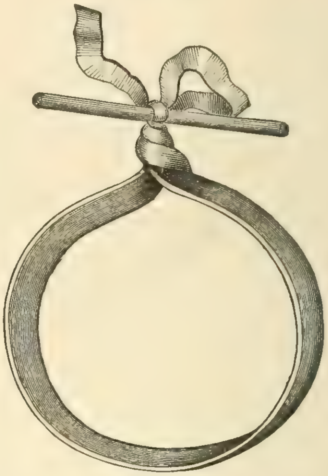
Plymouth, in England, as described in his "Currus Triumphalis e terebintho," published in 1679.[1] Morel's apparatus consisted of a thick compress, which was placed around the limb, and surrounded with a cord or small rope, under which were slipped two short sticks, by twisting which the cord was

Fig. 101.



Morel's tourniquet. (After Dionis.)

Fig. 102.



Morel's tourniquet improved. "The common tourniquet." (After Heister.)

drawn very tight[2] (Fig. 101). Morel's tourniquet was improved by Le Dran[3] and other surgeons (Fig. 102) by placing an additional pad immediately over the vessels and below the circular compress, by using only one stick for twisting the cord, and by placing beneath this a piece of paste-board—or, according to Garengeot,[4] of horn or leather (Fig. 103)—so as to render the pressure on the skin less severe, and thus avoid the risk of sloughing, which sometimes followed the use of Morel's instrument. But the greatest improvement in the tourniquet was that made in 1718 by the illustrious J. L. Petit[5] (Fig. 104)—le GRAND Petit, as he has been sometimes called to distinguish him from other less famous surgeons of the same name—and though, with its wooden plates and screw, we should think it but a rude contrivance, it was in all essential points the same instrument as the tourniquet employed at the present day.

As soon as surgeons had begun to emancipate themselves from the Hippocratic and Galenic doctrine of cutting only dead tissues, it was natural that they should adopt the Celsian method, and we accordingly find that the *circular* mode of amputation was practised at an earlier period than any of the *flap* operations. The first important modification introduced into the procedure of Celsus, was the suggestion, about the same time and apparently independently of each other, by Petit,[6] in France, and by Cheselden,[7] in Eng-

[1] Sharp's Critical Enquiry into the present state of Surgery, page 277. Second edition. London, 1750.

[2] Dionis, Cours d'opérations de chirurgie, Huitième Demonstration, p. 701. Paris, 1740. Dionis does not mention Morel's name, but says that the tourniquet was invented "a long time ago, during the seige of Besançon," by "one of the surgeons of the army;" and adds that it has been used ever since.

[3] Traité des opérations de chirurgie, p. 555. Paris, 1742.

[4] Traité des opérations de chirurgie, tome iii. p. 359. Paris, 1731.

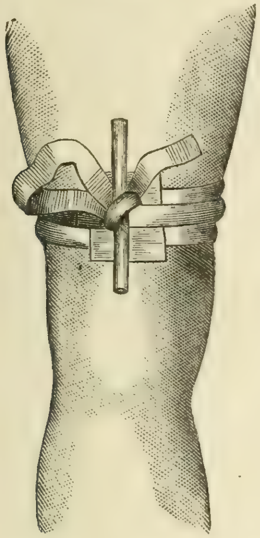
[5] Traité des maladies chirurgicales, etc., tome iii. p. 131. Paris, 1790.

[6] Op. cit. tome iii. p. 136.

[7] Notes to Le Dran's Surgery (Gataker's Translation), London, 1749. Le Dran (Traité des Opérations de Chirurgie, p. 555. Paris, 1742) describes the practice as his own, but Cheselden

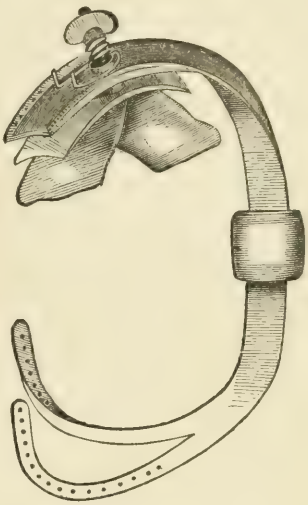
land, of the *double incision of the soft parts;* the skin and superficial fascia being divided first, and retracted, and the muscles cut by a second incision at the highest point thus exposed. It is right to add that, according to Velpeau, both of these writers were anticipated by Maggi, who is said by the

Fig 103.



Application of the common tourniquet. (After Heister.)

Fig. 104.



Petit's tourniquet. (After Petit.)

surgeon of "La Charité" to have employed the double incision in 1552. I have, however, read very carefully Maggi's account of amputation, and cannot find that he recommended a double incision, though he directed that an assistant should retract the soft parts as much as possible, so that they might more readily be brought down again to cover the bone.[1] Louis[2] practically returned to the Celsian method, dividing all the soft parts at the same level, but sawing the bone at a higher point—an important feature of the operation, the value of which Petit and Cheselden had overlooked. Louis also employed digital compression instead of the tourniquet, believing that the latter interfered with the retraction of the muscles. Valentin[3] (1772) advised that the position of the limb should be varied at different stages of the operation, so that the muscles of each part should be left as long as possible. With a similar view, Hey,[4] of Leeds, in amputating the thigh, divided the posterior muscles at a lower level than the anterior, in order that their greater tendency to retraction might thus be compensated for. To this surgeon, together with Alanson,[5] of Liverpool, and Benjamin Bell,[6] of Edinburgh, is due the im-

speaks of having suggested it independently many years before. In his account of the famous case of Samuel Wood (avulsion of arm and scapula), which, according to Haller, was first appended to the edition of his "Anatomy of the Human Body," published in 1741 (1740), Cheselden refers to the double incision as having been introduced by himself "about twenty years since" (Anatomical Tables, Tab. xxxviii. page 43. Boston, 1796). Lesne, Petit's pupil and editor, referring to Cheselden's publication of 1749, declares that Petit had publicly taught this method "more than thirty years before." (Traité des Maladies Chirurgicales, etc. [Petit], Discours Préliminaire, t. i. p. lxv.)

[1] Bartolomæi Maggii de vulnerum sclopetorum et bombardarum curatione tractatus. De Chirurgia Scriptores, etc. [ed. Conrad Gesner], fol. 267 et seq. Tiguri, 1555.

[2] Mémoires de l'Académie Royale de Chirurgie, t. ii. pp. 185, 248 ; t. iv. p. 159. Paris, 1819.

[3] Recherches critiques sur la chirurgie, p. 135.

[4] Practical Observations in Surgery, page 318. Philadelphia, 1805.

[5] Practical Observations on Amputation, etc., page 15. Second edition. London, 1782.

[6] System of Surgery, seventh edition, vol. vii. page 265. Edinburgh, 1801.

provement by which a sufficient covering was secured for the stump by dissecting up the skin and fascia so as to form a cuff, which was afterwards brought down over the muscles and bone. Bromfeild came very near suggesting this improvement, but, as Alanson points out, just missed it.[1] Alanson, who like Desault,[2] in France, preferred a straight knife to the heavy knives with concave edges, which were commonly employed in amputations, made his deep incision by applying the knife obliquely, and cutting the muscles into the form of a hollow cone; but other operators did not succeed in following his directions, finding that a knife thus used was more apt to make a spiral than a circular incision, and his peculiar mode of operating is now looked upon merely as a matter of historical interest. When the limb was a large one, Desault divided the muscles in two layers; he also divided the skin by two semicircular incisions, instead of making one complete circle, but, like Petit, he divided the bone on a level with the highest section of the muscles.[3] The operation of Bell and Hey—that "with a triple incision," as the latter called it,[4] the skin and fascia being first divided and dissected up for a sufficient distance, then the muscles cut and separated from the bone, and this finally sawn through at a still higher point—constitutes in all essential particulars the *circular operation* of the present day.

The first *flap operation* appears to have been suggested by Lowdham, of Exeter, as described by Young, of Plymouth, in his "Currus triumphalis e terebintho," published in 1679.[5] Velpeau,[6] however, declares that the operation was clearly described by both Leonidas and Heliodorus at a much earlier period. Velpeau's statement seems to me to be hardly justified: the opinions of Leonidas, or Leonides,[7] are known only through the writings of Ætius and Paulus Ægineta, the latter surgeon giving his views upon amputation, as already referred to;[8] while the only passage in the extant fragments of Heliodorus,[9] which can, with any degree of fairness, be considered a description of the flap operation, is his direction that in removing superfluous fingers a circular incision should be first made, and then straight cuts on either side from this, when two bodies or parts were to be raised up (εἶτα ἀναστέλλεται δύω σώματα);[10] but in his general remarks on amputation he certainly says nothing which can be reasonably construed into a description of the flap method.[11] Lowdham's and Young's operation was applied to the leg, and consisted in cutting from without inwards a long flap of skin and fascia from over the muscles of the calf. Verduin,[12] of Amsterdam, in 1696, and Sabourin, of Geneva, in 1702,[13] introduced the plan of forming a musculo-cutaneous flap from the calf of the leg, by transfixion, and attempted to control the bleeding by pressing this firmly against the end of the stump; Verduin's flap was adopted by Garengeot,[14] who, however, ligated the bleeding vessels, and thus perfected the ordinary flap operation of the leg as it is still often practised at the present day. O'Halloran,[15] an Irish surgeon, likewise employed this mode of

[1] Chirurgical Observations and Cases. By William Bromfeild, etc., vol. i. page 151. London, 1773.

[2] Œuvres chirurgicales, seconde partie, p. 491. Paris, 1798.

[3] Op. cit., pp. 480, 492.

[4] Op. cit., p. 317.

[5] La Faye, Histoire de l'amputation à lambeau, etc., Mém. de l'Acad. Royale de Chirurgie, t. ii. p. 169. Paris, 1819.

[6] Nouveaux éléments de médecine opératoire, t. ii. p. 360.

[7] Haller, Bibliotheca chirurgica, t. i. p. 79.

[8] Vide supra, page 553.

[9] Op. cit., p. 158.

[10] This was rather an anticipation of Ravaton's double-flap method than of Lowdham's operation.

[11] Op. cit., p. 156. Vide supra, page 553.

[12] Mangetus, Bibliotheca scriptorum medicorum, lib. xx. t. ii., pars ii., p. 493, and Garengeot, Traité des opérations, t. iii. p. 393.

[13] La Faye, loc. cit., p. 170.

[14] Mém. de l'Acad. Royale de Chirurgie, t. ii. p. 180.

[15] The Medical Museum, vol. iii. p. 65. London, 1764.

amputation, but did not close the stump until the flap was already covered with granulations. The earliest *double-flap* amputation (if we except Heliodorus's operation on the fingers), appears to have been practised by Ravaton,[1] a French surgeon, about the year 1739. He applied this method of operating to the thigh, making first a circular incision down to the bone, and supplementing this by longitudinal incisions in front and behind, making thus two square, muscular, lateral flaps, at the point of junction of which the bone was then divided. Vermale[2] modified and improved this procedure by making the flaps of a rounded or somewhat oval shape, and by forming them by transfixing the limb with a long knife and cutting from within outwards. La Faye's suggestion[3] to use a knife curved on the flat that it might better slip around the bone, appears more ingenious than practically valuable.

The flap operation, in one or other of its forms, was soon adopted by other surgeons, and with various modifications was finally brought into ordinary use through the example mainly of Liston and Guthrie in England, of Dupuytren, Roux, and Larrey in France, and of Klein and Langenbeck in Germany. All the various forms of amputation which have been since employed, may be regarded as varieties of these two principal methods, the flap and the circular.

Conditions calling for Amputation.

It is not intended, of course, in the following paragraphs, to enumerate and describe all the various contingencies which may determine a surgeon to resort to amputation. There is hardly any form of injury, or variety of disease, capable of affecting a limb, which may not, under particular circumstances, whether as regards the constitution and hygienic condition of the patient, or the individual and peculiar features of the special lesion, necessitate a resort to this operation. All that is meant to be done here is to bring together, in a compendious way, brief references to the more important conditions which, as a rule, render imperative the removal of a limb, so that the reader may obtain, as it were, a bird's-eye view of the subject, and may thus be enabled to realize to what a vast diversity of cases the "humane operation" of amputation is applicable.

Avulsion of a Limb.—In the first place, it can be readily understood that when any considerable part of an extremity has been torn off and entirely separated from the body, there is commonly no alternative to immediate amputation. The operation may indeed be said to have been already effected by the force which caused the injury, and the surgeon's part is merely to trim off the hanging shreds of tissue, and put the wound in such a condition that it may heal more readily, and that the resulting stump may be of better shape and more useful than if the process of repair had been entirely abandoned to the efforts of nature. Even though the part be not altogether separated, if it be hanging merely by integument and fascia, the great vessels as well as the bone and most of the muscles having been divided, the surgeon's duty is to amputate. A few authentic cases are no doubt on record in which small portions of the body, tips of the fingers, or bits of the nose or ears, have been re-applied after complete separation, and have become reunited; but even these restorations are, in this climate at least, so rare, that their possibility may be practically disregarded; while in respect to the cases which we

[1] La Faye, loc. cit. p. 174. Le Dran, op. cit. p. 564.
[2] La Faye, loc. cit. p. 175. Le Dran, op. cit. p. 567.
[3] Loc. cit.

occasionally find described in journals, of large portions, hands or arms, being thus re-connected with the body, I must confess to entire incredulity.

Compound Fractures and Luxations very frequently necessitate removal of the injured part. Most of the primary amputations performed in our large city hospitals are in cases of compound fracture, and though limbs are undoubtedly saved now which in past times would have been sacrificed, yet with the increase of railway travelling and the more general employment of heavy machinery in manufactures, the number of accidents of this nature has been so augmented that amputation for injury becomes, year by year, a more frequent operation in hospital practice. The propriety of amputation in compound fractures may be determined by various considerations:—

(1) *Great comminution of the bones* may of itself be a cause for amputation. In the upper extremity, conservative measures may often be successful, loose or partially detached fragments being removed, and projecting ends of bone sawn off if necessary to effect reduction; but in fractures of the lower extremity, if the fragments which require removal involve the whole thickness of the femur or tibia, the resulting limb, should recovery follow, would in all probability be rather an encumbrance than a benefit, and under such circumstances amputation should ordinarily be resorted to.

(2) *Laceration of a large artery*, in connection with compound fracture, usually calls for amputation. Here, again, a distinction may be made between injuries of the upper and those of the lower extremity; in the case of the former, an attempt may sometimes properly be made to save the limb by tying the vessel in the wound, or even by securing the main trunk above, but in the case of the lower extremity, unless the bleeding artery can be readily found and ligated in the wound itself, amputation will be found the safest mode of procedure. So, too, in case of secondary hemorrhage occurring as a complication of compound fracture in the lower extremity, amputation will commonly be necessary.

(3) *Great contusion and laceration of the muscles*, even if the great vessels be uninjured, may be considered to indicate amputation in many cases of compound fracture. A limb which has been crushed by the wheels of a railway train, almost invariably requires amputation, the muscles and other deep-seated tissues being torn, and, as it were, *pulpefied*, while the skin may be comparatively uninjured. In such a case the operation should, as a rule, be performed at a higher level than that at which the skin is found to be separated from the subjacent tissues, as otherwise sloughing of the flaps will be apt to follow, and a second amputation may, perhaps, be required.

(4) *Compound fracture into the knee-joint* may be considered a cause for amputation, and the same operation will often be required in cases of compound fracture involving the *ankle*. In similar injuries involving the other joints of the body, and, under favorable circumstances, in the instance of the ankle, excision should be the surgeon's first thought, and may often be properly substituted for amputation.

Compound dislocations of large joints are among the most serious injuries to which the human frame is liable, and, in my judgment, almost always require operative interference; in the case of the hip or ankle, or of the articulations of the upper extremity, excision may be preferred, but in the case of the knee amputation is the safer remedy, and may, indeed, be said to be imperatively demanded.

Lacerated and Contused Wounds, even when unattended by injuries of the bones or joints, may require amputation. Operatives in mills not unfrequently

have their arms caught in portions of the machinery, and drawn between rollers revolving in opposite directions; in many of these cases, provided that there be no fracture, expectant measures may undoubtedly suffice, and I have frequently saved limbs thus injured by the use of irrigation, with cool or tepid water, according to the season of the year. In some instances, however, the destruction of the integument and muscles is so extensive that the inevitable sloughing would render the limb, even if it should be preserved, a mere useless appendage, and, under such circumstances, amputation should be resorted to, as not only greatly shortening the duration of the treatment, but as delivering the patient from many of the secondary risks of wounds to which he would otherwise be liable. The same may be said in regard to certain injuries caused by railway trains or heavily loaded wagons; a foot and ankle from the greater part of which all the soft tissues have been stripped, or bruised into an indistinguishable pulp, can never be anything but a source of suffering and discomfort to its possessor, and under most circumstances should be removed as promptly as possible. In this category, too, may be placed the frightful lacerations sometimes caused by the teeth and claws of *wild animals;* these are, of course, more common in countries of which such animals are natives, than in our own; but they are occasionally met with among the attendants or visitors at menageries, and I have myself had occasion to see wounds inflicted by a Polar bear, a lion, and a Royal Bengal tiger.

The last-mentioned case occurred during my student days, and the victim, a young woman, was admitted to the Pennsylvania Hospital, where she came under the care of the late Dr. Edward Peace. The injury, inflicted by a blow from the claws of the animal, was a very severe laceration of the arm, involving the brachial artery. Primary amputation at the shoulder-joint was resorted to, and the patient made an excellent recovery.

The case of bear-wound occurred in a man who was, a few years since, under my care in the University Hospital; there was a tolerably severe and painful laceration of the arm and shoulder, but not such as to require operative interference, and the wound healed readily under simple dressings.

The case of lion-wound was the only one of the three which terminated fatally. This occurred in a man aged 25, a professional "lion-tamer," who, in the course of his daily rehearsal, placed his head in the lion's mouth, when the animal unexpectedly closed his jaws. The by-standers rushed to the rescue, and with clubs and iron bars forced the wild beast to relax his hold, but, unfortunately, his victim did not make his escape with sufficient promptness, and the lion again attacked him, throwing him down, and this time seizing him by the fleshy part of the thigh. I did not see the patient until the next day, when he was not in a condition to admit of any operation. The injured thigh was already the seat of traumatic gangrene, which had set in within eighteen hours after the reception of the injury; the limb was enormously swollen, emphysematous and crackling from the gaseous products of decomposition, and discharging from its numerous wounds, some of which were two or more inches in length, a bloody, sanious, and very offensive fluid. The pulse was running at the rate of 172 beats in the minute, and it was quite evident that a fatal issue was impending. Death occurred shortly after the gangrene reached the trunk, the whole duration of the case having been just forty-eight hours. Had amputation at the hip-joint been performed before or immediately upon the occurrence of gangrene, there might have been some slight hope of the patient's surviving. This case was under my care at the Episcopal Hospital in April, 1872.

GUNSHOT INJURIES often call for amputation. The increased power of destruction possessed by modern implements of warfare, to a great extent counterbalances the improvements which have been made in the treatment of wounds; so that though, by the introduction of the operations of excision

and resection into military surgery, many limbs can now be preserved which would formerly have been condemned to removal, yet the proportion of cases in which the army surgeon is compelled to amputate, is probably almost if not quite as large as when, though surgery was less efficient, the injuries with which it had to deal were less severe. The conical ball, propelled by the modern rifled firearm, splits and shatters the bone which it strikes so severely, as very often to defeat any hope of doing good by expectant treatment; and when simple extraction of fragments is not sufficient, and the surgeon has to choose between amputation and resection, the former will frequently be found the more eligible operation.

Various Lesions of Arteries require amputation. Simple *wounds* of arteries are, of course, usually amenable to milder measures, and subcutaneous *ruptures or lacerations* of the great vessels may often be successfully treated by laying open the part, after controlling the circulation with a tourniquet or Esmarch's tube, or even with digital compression, and by securing the artery as if it had bled in an open wound. In certain situations, however, as when the popliteal artery is the seat of rupture, amputation will commonly be needed. Again, *traumatic aneurisms*, or spontaneous aneurisms which have become *diffuse*, may require amputation; this rule particularly applies to aneurisms of the popliteal artery, and of the deep arteries of the leg, and to traumatic aneurisms in the axilla. Amputation has also been successfully practised as a modified distal ligation in cases of subclavian aneurism. Finally, amputation may be demanded in cases of *secondary hemorrhage*, whether from a wounded artery or from one previously ligated in its continuity. The reason that amputation is often more successful under such circumstances than any other measure, can be readily understood when it is remembered that secondary bleeding almost invariably comes from the distal end of a vessel (where the repair is less perfectly effected than at the proximal end), and that only by amputation can the *vis a fronte* which induces the supply of blood to the distal end be got rid of.

Heat and Cold.—Amputation is not unfrequently rendered necessary by the destructive influence of *heat* or *cold.* In cases of *frost-bite*, the dead parts, if limited in extent, should be allowed to drop off spontaneously; if a whole hand or foot be involved, the sphacelated mass may be removed by an incision through the dead tissues, and then, when the lines of demarcation and separation have been fully established, a formal operation may be practised. So, too, in cases of *burns or scalds*, no operation should as a rule be attempted until after the sloughs have all become detached, when, if it be evident that a cure is not to be expected from nature's unaided efforts, amputation may be resorted to with the best prospects of a favorable result. The same operation may also be called for at a later period in cases of great deformity resulting from cicatricial contraction, or when, as sometimes happens, old cicatrices become the seat of malignant growths.

Mortification from whatever cause, when the death of the part goes beyond the formation of a mere superficial slough, usually demands amputation. The ordinary rule, and one that under most circumstances should be strictly adhered to, is that no amputation should be undertaken until after the complete establishment of the line of separation; the reason is obvious—if the surgeon cut through parts the vitality of which is, as it were, hanging in the balance, the additional injury inflicted by the knife may of itself be sufficient to turn the scale, and an amputation under these circumstances is apt to be followed by a renewal of the gangrenous process. Hence when death of a

part results simply from the intensity of the inflammatory process, as in the cases of frost-bite and burn, already referred to, no operation should be done while the mortification is still extending, but the surgeon should await nature's indication that the limit of the destructive process has been reached, and may then amputate at any point above the line of separation which may be found convenient. There are, however, exceptions to this ordinarily well-founded rule. Thus in the purely local forms of gangrene which result from direct injury, as in severe cases of compound fracture in which for some reason primary amputation has not been practised, the limb should be removed as soon as the signs of mortification are unequivocally manifested; delay under these circumstances would commonly result in the patient's death before time had been given for the formation of a line of separation. Again, in that frightful form of mortification which is variously known as the true "traumatic or spreading gangrene," "bronzed erysipelas," "gangrenous emphysema," etc., the only hope, and that, it must be confessed, but a slight one, consists in immediate amputation at a point sufficiently removed from the seat of disease to render unlikely a recurrence of gangrene in the stump; this was the form of gangrene which occurred in the case of fatal injury by a lion which I have already referred to; it is most common in connection with bad compound fractures and severe lacerated wounds, though it may follow comparatively slight injuries, and is particularly apt to occur in persons who are suffering from previously existing visceral disease, and especially from organic affections of the kidney.

There is another form of gangrene which may require immediate amputation, and that is where death of a part results from an arterial lesion at a distant point, as where mortification of the foot depends upon a gunshot wound of the femoral artery. The gangrene in these cases first displays itself through a change in the coloration of the affected part, which is in the beginning pale and tallow-like, and afterwards mottled and streaked, while numbness is succeeded by complete insensibility. Guthrie's advice as to the course to be pursued under such circumstances, appears to be judicious; this is that while the gangrene remains limited to the toes or foot, the surgeon should delay, in hope that it will not extend further; but that as soon as the disease shows a tendency to spread above the ankle, amputation should be performed at that point at which experience has shown that the morbid process is likely to be arrested, that is, a short distance below the knee. If the upper extremity should be similarly affected, the point at which the arm should be removed would be the shoulder-joint.

Dry Gangrene, affecting the extremities of old persons, seldom admits of active treatment, the disease almost invariably recurring in the stump when an amputation is attempted. To avoid this risk, it has been recommended by James, of Exeter, and other surgeons, that, for gangrene affecting the toes, the operation should be done in the upper part of the thigh, where the tissues would presumably be more healthy than at a lower point; but it is obvious that the constitutional state of the patient, in most cases of senile gangrene, would render such a mode of treatment hazardous in the extreme. Greater success attends amputation for those forms of dry gangrene which are occasionally met with in young persons, as the result for instance of embolism; but even in such cases, the surgeon should hesitate about interfering until the formation of a line of separation shows that nature is making an effort to throw off the portion of which the vitality has been lost. Amputation may also be required in cases of *Hospital Gangrene*, or sloughing phagedæna, either after the morbid process has been arrested, on account of the great loss of substance, or even during its continuance, should profuse bleeding occur from the opening of a large artery. In the latter case, care should

be taken to amputate through healthy tissues, and every precaution should be observed to avoid the risk of inoculating the wound of operation with the discharges from the original seat of disease.

Various Diseases of the Bones and Joints may necessitate removal of the affected limb. If either alone be diseased, less sweeping measures may suffice, excision taking the place of amputation in favorable cases of joint-disease, and the extraction of sequestra, Sédillot's operation of *évidement* (gouging), or, in some instances, complete sub-periosteal resection, usually proving satisfactory when the bones only are affected without implication of the neighboring articulations. Much, however, as I admire the practice of "conservative surgery," and striving as I invariably do to substitute excision and the other operations which have been referred to, for amputation, in all suitable cases, I cannot doubt that there will always be a considerable residuum of bone and joint-affections, in which the "humane operation" will offer the only chance of recovery.

Morbid Growths not unfrequently become causes for amputation. It may even happen that a non-malignant tumor, by its size and weight, by its relations to the great vessels and nerves of an extremity, or, if suppuration and ulceration have occurred in it, by the exhaustion caused by profuse discharge, may render removal of the affected limb a more promising operation than an attempt to separate the growth from the surrounding tissues; while in the case of malignant tumors of the extremities, and particularly those involving the bones, including (as clinically malignant) the sarcomata, cartilaginous growths, etc., amputation is commonly the sole remedy. It is true that, in some few instances, excision of the affected portion of bone has been advantageously resorted to, as in the examples recorded by Lucas and Morris, in which myeloid growths of the forearm were thus successfully dealt with; but in the majority of cases, amputation will be found the safer measure, and under these circumstances may usually be resorted to with every prospect of a favorable termination.

Tetanus has been looked upon as an affection calling for amputation, and a cure has occasionally followed the operation. Laurent has collected seventeen cases of minor, and twenty-four of major amputation for tetanus, with eleven recoveries in either category, or, taking both together, a proportion of successes of nearly fifty-four per cent. In most instances, however, the cases appear to have been examples of subacute or chronic tetanus, in which a good result may often be obtained by internal treatment alone, and on the other hand the milder operations of nerve-stretching and neurotomy have given at least as good results as amputation; we may probably say, therefore, in view of all the evidence which has been produced in respect to the matter, that while, if the operation appear to be otherwise indicated, the onset of tetanus may be considered an additional reason for resorting to amputation, this should not be indiscriminately employed in all instances of tetanus originating in wounds of the extremities, without regard to the other circumstances of the particular case.

I cannot look upon amputation as a justifiable procedure in cases of *hydrophobia*, nor, unless under very exceptional circumstances, in those of *poisoned wounds* from the bites of serpents, etc.

Deformities.—Finally, amputation may be sometimes practised in cases of congenital malformation, as in some instances of neglected club-foot, or in cases of limbs deformed by accident or disease, the result of vicious cicatri-

cial contraction, union of fractures in bad positions, faulty anchylosis, etc. Amputation in cases such as these, must be considered an *operation of election*, or *of complaisance*, and should not be resorted to, therefore, except under circumstances as regards the age and general condition of the patient which would render an unfavorable termination exceedingly improbable, and even then not without a full appreciation of the risks of the operation on the part of all concerned.

Instruments required for Amputation.

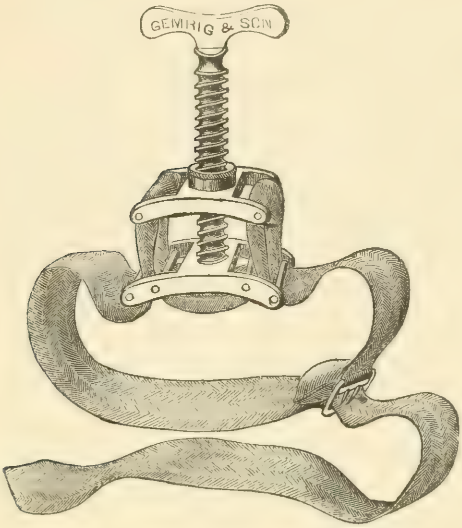
Before undertaking an amputation, as, indeed, before attempting any operation, the surgeon should run over in his mind all the various instruments and appliances that may possibly be required by the several contingencies which may arise. He should see that all the necessary implements are at hand, and in working order; there can be nothing more awkward than for the surgeon, after making his flaps, to discover that the saw has been forgotten, or, when the limb has been removed, that he is likely to run short of ligatures, or that the needle with which he proposes to sew up the wound, has no point, or a broken eye. Nor is the inconvenience to the operator the worst result of this kind of improvidence, for the delay caused in procuring the missing articles may prove very prejudicial to the patient.

The instruments needed for amputations are a tourniquet, or other suitable means for controlling the circulation during the various steps of the operation, knives of various forms and dimensions, saws of different kinds, bone-nippers or cutting pliers, a pair of strong forceps for holding bone, artery forceps and tenacula, spring-clips and serre-fines, ligatures, retractors, sutures and suture needles, common dissecting forceps, and scissors. Besides these, the necessary means of dressing the stump should be provided; laudanum, olive oil, or whatever substance the surgeon intends to employ as a dressing, adhesive plaster, sheet lint or old linen, oiled silk or waxed paper, charpie or oakum, bandages, pins, etc.

Tourniquet.—As already mentioned, the first attempt to control bleeding *during* an amputation appears to have been made by Archigenes, who sometimes placed a fillet around the whole limb, and sometimes tied or sewed up the vessels at a point above that at which it was intended to amputate. The fillet answered its purpose very imperfectly, and the invention of Morel, by which sticks were thrust under the band, and twisted around so as to compress the limb tightly, was unquestionably an improvement. Morel's tourniquet as further modified by Ledran is still employed occasionally with advantage in cases of emergency, under the name of the "garrot" or "Spanish windlass." The best tourniquet for ordinary use is in all important points the same as that introduced in the early part of the last century by Petit, and consists of two metal plates, the distance between which can be regulated by means of a screw, and which are connected by a strong silk or linen strap, which is meant to pass around the limb, and which is provided with a buckle to prevent its slipping (Fig. 105). The plan which I have now for a good many years adopted in applying the tourniquet is as follows: The surgeon, taking an ordinary three-inch or four-inch roller bandage, makes, by unrolling and again folding one end of it, a somewhat flat compress, which is placed immediately over the main artery of the limb at a point at which its pulsations can be distinctly recognized. This compress is fixed by a few circular turns of the bandage, and the rest of the roller is then laid as a second compress somewhat obliquely across the vessel, so as to force inwards the first compress,

and keep up the tension even if the tourniquet-plate should be slightly displaced to one or the other side. The tourniquet is next applied, with its plates closely approximated, and placed immediately over the compresses, so as to exercise pressure in the line from the compresses through the vessel, to the subjacent bone. The strap is then drawn quite tight, and secured by the buckle, when a few turns of the screw will be found to completely control the circulation. It is desirable that the plates of the instrument should not be separated by more than half the length of the screw, as if separated by its full extent, the instrument becomes, as it were, top heavy, and is apt to slip.

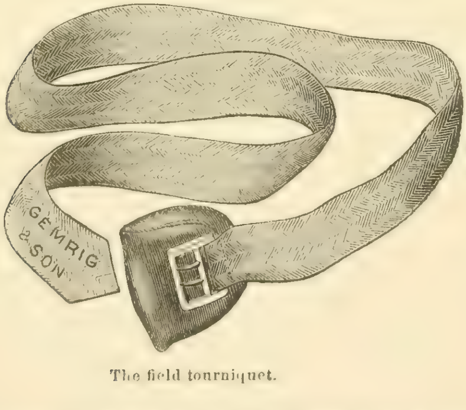
Fig. 105.



The modern tourniquet.

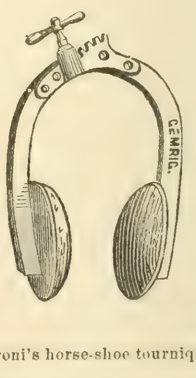
It is sometimes supposed that, provided that the compress be placed over the artery, it makes no difference to what part of the limb the tourniquet plate is applied. This is an error, as can be readily perceived by reflecting upon the mechanism of the instrument. The tourniquet is so arranged that it makes *direct* pressure but at two points; immediately below the plate, and at a point diametrically opposite; at every other point of the circumference the pressure produced by tightening the strap is *oblique* or *gliding*. Hence the inevitable effect of placing the plate elsewhere than either immediately over the artery, or diametrically opposite to it, will be to push the vessel more or less to one side, when the circulation may not be controlled though the instrument be applied as tightly as possible. Hence,

Fig. 106



The field tourniquet.

Fig. 107.



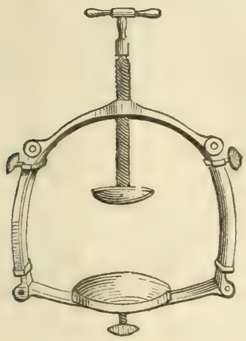
Signoroni's horse-shoe tourniquet.

whenever it is practicable, the tourniquet plate should be fixed as above directed, immediately over the artery; when this cannot be conveniently done, as in the case of the axillary, or in that of the popliteal artery, it should be placed at a point diametrically opposite, over the point of the shoulder in the case of the former, and just above the patella in that of the latter vessel.

Various other forms of tourniquet have been devised by surgeons, but none

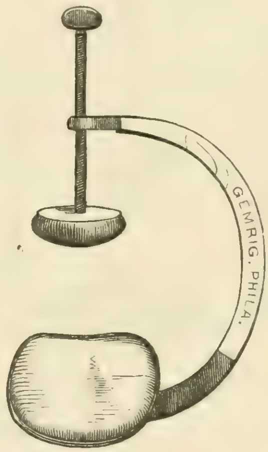
of them approach in value to the familiar instrument of Petit. The *field tourniquet* (Fig. 106), numbers of which are sometimes distributed to troops in time of war, consists merely of a strap and buckle, with a pad to go over the artery; unless very firmly applied, it is apt to do harm rather than good by obstructing the venous, without controlling the arterial circulation, and is certainly inferior to the Morel tourniquet or Spanish windlass. Other instruments, which seem to me better adapted for the compression treatment of aneurism, or for temporary employment in cases of accidental hemorrhage, than for use in amputations, are the *horse-shoe* or *Signoroni's tourniquet* (Fig. 107), *Skey's tourniquet* (Fig. 108), *Hoey's clamp*[1] (Fig. 109), and *Gross's arterial*

Fig. 108.



Skey's tourniquet.

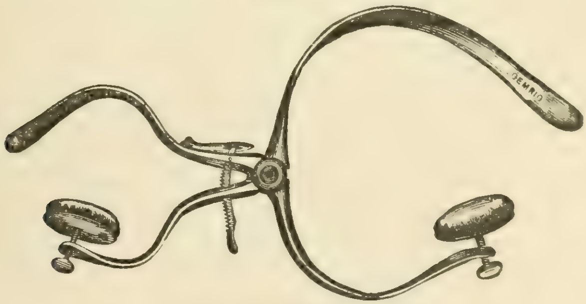
Fig. 109.



Hoey's clamp.

compressor (Fig. 110). Under certain circumstances, however, as when it is desired to compress the abdominal aorta or common iliac artery preparatory to amputating at the hip-joint, the Petit's tourniquet is inapplicable; and here the greatest benefit may be derived from the use of one of these other

Fig. 110.



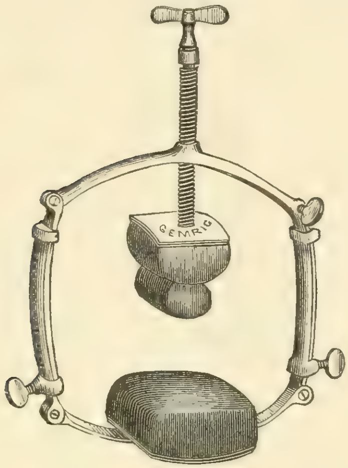
Gross's arterial compressor.

instruments. The compressor first employed in this operation by Prof. Joseph Pancoast, and since frequently used in this city (Philadelphia) for hip-joint amputations, was a large-sized Skey's tourniquet, to which Prof. Pancoast added a second pad (Fig. 111), so as to make very deep and firm pressure

[1] This instrument is sometimes credited to Dupuytren.

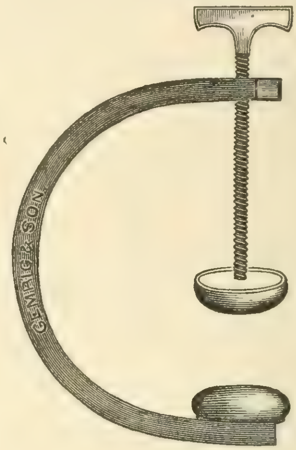
upon the aorta. Without knowing of Prof. Pancoast's operation, Prof. Lister, formerly of Glasgow and Edinburgh, and now of King's College, London, adapted Hoey's clamp to the abdominal aorta (Fig. 112), and this instrument is the one generally employed in England. I have used both in amputating at the hip-joint, and have no hesitation in declaring my preference for Prof. Lister's instrument, as being much simpler and more readily adjusted than the other.

Fig. 111.



Pancoast's abdominal tourniquet.

Fig. 112.

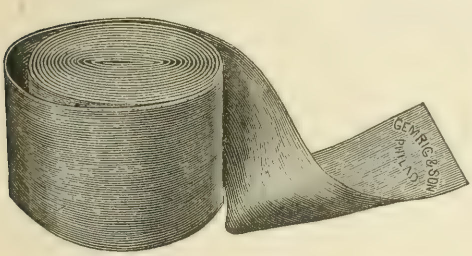


Lister's aortic compressor.

There have always been, and, probably, always will be, two schools in operative surgery: that which makes light of the loss of blood, looking upon it as a trifling matter, and that which deprecates any unnecessary expenditure of the "vital fluid," considering every drop that can be saved as of value to the patient. Hence we find that some surgeons have objected to the use of the tourniquet in amputation, preferring to rely exclusively upon compression of the main artery by the fingers of an assistant. It is said that the tourniquet produces venous congestion, and, in the circular operation, interferes with the necessary muscular contraction; and of late years it has been imagined that, by inducing venous thrombosis at the point of application, it predisposes to the occurrence of pyæmia. The last-mentioned objection is hardly worthy of serious consideration; if venous thrombosis, *per se*, were the cause of pyæmia, we should have pyæmic complications in almost all cases of simple fracture. By taking care to elevate the limb, or even to surround it with a firm bandage applied from below upwards, before screwing down the tourniquet, the interference with the venous circulation may be reduced to a minimum; and nothing can be easier than to saw off an additional piece of bone, after securing the vessels, if the retraction of the muscles should render it necessary. Guthrie and Hennen speak of the operator compressing the artery with one hand while he amputates with the other; but such unnecessary feats seem to me rather adapted to exhibit the skill and boldness of the surgeon than to promote the welfare of the patient. Safety should never be sacrificed to brilliancy, and there can be no doubt that a well-applied tourniquet renders an amputation safer than the best directed manual pressure; for while this can only arrest the flow of blood through the main trunk, the tourniquet controls all the arteries at once, and it is often the smaller vessels that give the most trouble.

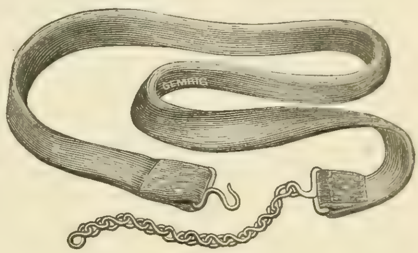
ESMARCH'S APPARATUS.—I have already mentioned the plan of elevating the limb and bandaging it from below upwards, before screwing down the tourniquet, in order to prevent the loss of venous blood besides controlling arterial hemorrhage. An improvement upon this procedure has been introduced within a few years by an Italian surgeon, Silvestri, and by Esmarch, an eminent surgeon of Kiel. Esmarch's apparatus (Figs. 113, 114) consists of a gum-elastic bandage and tube. The bandage is accurately applied to the

Fig. 113.



Esmarch's elastic bandage.

Fig. 114.



Esmarch's elastic tube.

limb upon which the operation is to be performed, from below upwards, and with sufficient firmness to render the part quite bloodless. The elasticity of the bandage renders it unnecessary to make reverses, and with a little care the whole extremity can be covered in without leaving any gaps between the turns. The tube, which may be either round or flattened (as in Fig. 114), is next wound firmly four or five times around the limb, at the point of termination of the bandage, and is secured either by tying or by a hook and chain. The bandage being then removed, the part is left fully exposed, and entirely free from blood. In the early days of "artificial ischæmia," as this method of rendering a limb bloodless has been called, an India-rubber cord was sometimes used instead of the tube, thus making much firmer constriction than was really necessary, and leading in some cases to paralysis or even gangrene of the limb to which it was applied, while in other instances the pressure of the bandage, by dislodging clots and forcing them upwards into the larger veins, caused, it is said, pulmonary embolism and death. But the principal objection that has been urged against the employment of Esmarch's apparatus is the liability to consecutive hemorrhage. There is no doubt that, unless special precautions be observed, free capillary oozing will inevitably follow when the tube is removed, and in some cases this may prove a very serious complication: thus I am cognizant of one case in which, after the use of the tube and bandage in an excision of the knee-joint, capillary bleeding began when the tube was removed, and continued until the patient's death. Various plans have been adopted to prevent this oozing: Nicaise advises compression of the wound with a sponge dipped in a two-per-cent. solution of carbolic acid; Riedinger applies to the wound a current of induced electricity; and Esmarch himself recommends that, after tying all the vessels that can be found, the wound should be closed with deep sutures, dressed, and elevated to a vertical position before the tube is removed, and that this position should be maintained for at least half an hour afterwards.

The plan which I have myself adopted, and which I can confidently recommend as being less troublesome, and at least as satisfactory, as any of those that have been mentioned, is based upon a consideration of the *cause* of the capillary oozing referred to. The firm pressure of the elastic tube, if continued for more than a very short time, produces temporary paralysis of the

vaso-motor nerves of the part affected, and, as a consequence, dilatation of all the vessels; the normal contraction and retraction of these does not take place, and, when the tube is removed, profuse bleeding occurs and continues until the vessels regain their natural tone. Now, except in cases of necrosis, etc., in which the bleeding can be restrained by firmly stuffing the wound with lint before the removal of the tube, it is evident that, in order to prevent hemorrhage, the arterial circulation should still be controlled after the tube has been taken off, and while the vessels are recovering themselves. This may be conveniently and effectively done by combining the use of the *tube* with that of the ordinary *tourniquet.* My plan is to place a tourniquet in position, but not screwed down, over the main artery of the limb, and then to apply the Esmarch tube a few inches above the point at which I intend to amputate. As soon as the principal vessels have been secured—and these should be readily recognized through a knowledge of their anatomical relations—the tourniquet plate is screwed down and the tube removed. No bleeding follows, because the circulation is still thoroughly controlled by the tourniquet, and by the time that the remaining arteries requiring ligatures have been tied, the vessels will have regained their tone, and the tourniquet can be withdrawn without any risk of bleeding following.

In amputations for injury, where there is much laceration of the tissues, I commonly apply the Esmarch tube without the elastic bandage; in amputations for disease, however, or where there is not much laceration, and, generally, in operations other than amputation, both should be employed. Apart from the very great convenience to the surgeon, in many cases, of having the field of operation free from blood during his manipulations, I am well convinced that the judicious use of Esmarch's method will enable a certain number of lives to be saved by operation, which would otherwise inevitably be lost.

Various ingenious modifications of Esmarch's apparatus have been suggested by Foulis, H. L. Browne, C. B. Nancrede, and other surgeons; but I have no personal experience of any of these devices, of the practical value of which I confess to have some doubts. M. Houzé de l'Aulnoit employs a simple band of caoutchouc, applied while the limb is held in a vertical position, and dispenses with the preliminary bandage.

Amputating Knives.—The knife formerly used for the circular operation had but one edge and a very heavy back, being shaped somewhat like a sickle (Fig. 115); and a very good knife it was, cutting through the soft tissues

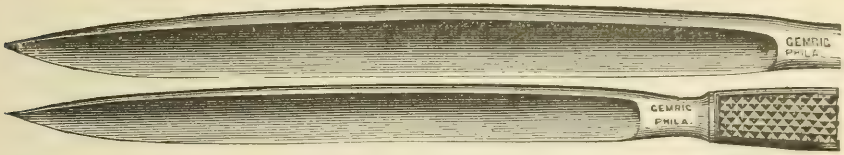
Fig. 115.

Old knife for circular amputations.

almost by its own weight, and doing its work in a very satisfactory manner. The modern amputating knives, however, which are intended for use in either the circular or the flap operation, have a sharp point and are usually double-edged for an inch or more at the extremity (Figs. 116, 117). The length of the knife should be about one and a half times the diameter of the limb to be removed, and its breadth from three-eighths to three-fourths of an inch. Thus a knife with a cutting edge of eight or nine inches will be sufficiently long for most amputations of the thigh, while one with an edge of six or seven inches will be ample for smaller limbs. *Double-edged catlins* (Fig. 118) are used principally for the forearm and leg, and are con-

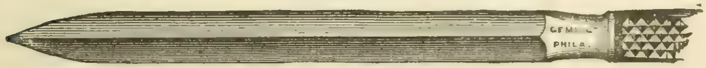
venient in clearing the interosseous space for the application of the saw; their breadth should not be greater than three-eighths of an inch. In addition to the amputating knives which have been described, the surgeon should

Figs. 116, 117.



Modern amputating knives.

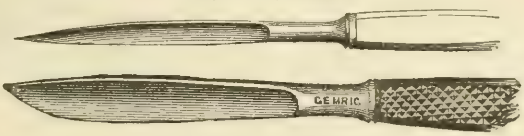
Fig. 118.



Double-edged catlin.

be provided with one or more strong bistouries or scalpels (Figs. 119, 120), which should be about three inches in length, while for removing the fingers

Figs. 119, 120.



Bistoury and scalpel.

it will be found advantageous to employ a very slender knife with a heavy back (Fig. 121). Two inches in length and an eighth of an inch in width

Fig. 121.

Knife for finger amputations.

may be considered suitable dimensions for the blade of such an instrument. These measurements are rather smaller than those ordinarily given in works on Operative Surgery, but they are such as my own experience leads me to recommend. Indeed, for my own part, I greatly prefer a small knife to a large one, and not unfrequently employ what is called a "metacarpal knife," with a three-inch blade (Fig. 122) for the largest amputations, having found

Fig. 122.

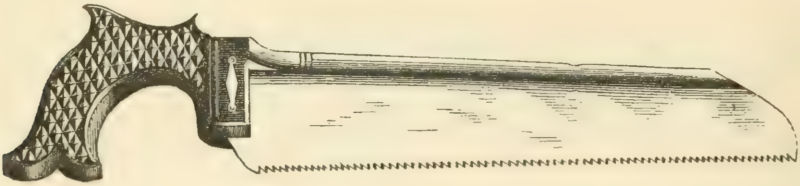
Metacarpal knife.

it amply sufficient even for disarticulation at the hip-joint. The handles of amputating knives should be large enough to afford a firm grasp, and if made of roughened ebony are less likely to slip than if of bone or ivory.

Saws.—The principal varieties of saw used for amputations are the ordinary flat-bladed saw (Fig. 123) and the bow saw (Fig. 124), of which my own

preference leads me to recommend the former. It should be about ten inches long, with a width of two inches and a half, should be very strong, and should

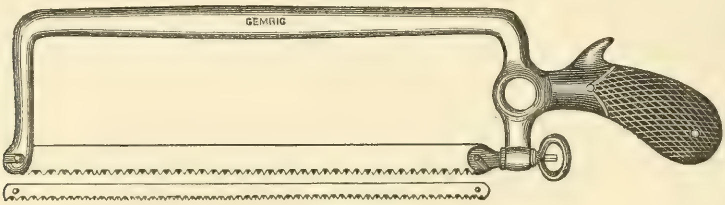
Fig. 123.



Amputating saw.

be furnished with a heavy back, so as to afford additional firmness. The teeth should not be too widely set—just enough to prevent the instrument

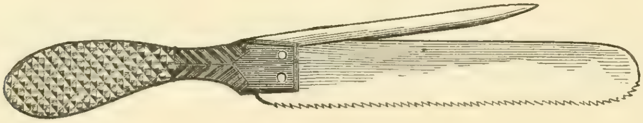
Fig. 124.



Bow saw.

from binding as it passes through the bone. A small saw, with a movable back (Fig. 125), will sometimes be found useful for amputations through the

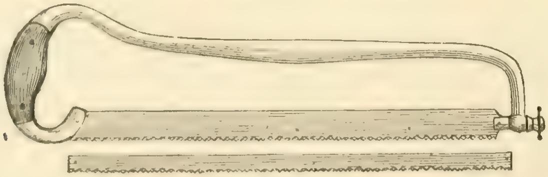
Fig. 125.



Small saw with movable back.

hand or foot. Other forms of saw have been recommended for use in the operation of amputation, among which I may particularly mention the instruments which bear the names of Rust and Butcher (Figs. 126, 127). The

Fig. 126.

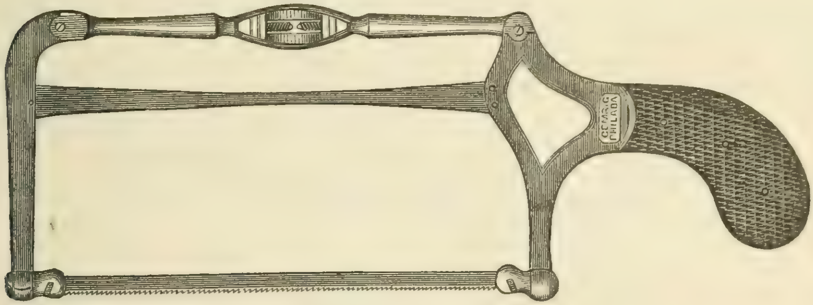


Rust's saw.

former seems to me to present no advantage over the ordinary saw, while the latter, though almost indispensable in certain excisions, as of the knee, appears

to be less well adapted for amputations; it has been claimed for it, as in its favor, that its use enables the surgeon to saw the bone in a curved direction;

Fig. 127.

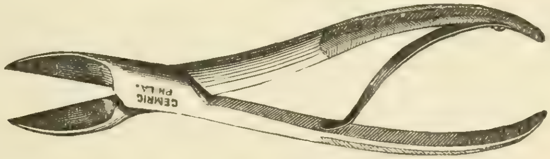


Butcher's saw.

but I confess that I regard such a mode of dividing the bone as undesirable, and as unnecessarily incurring the risk of necrosis and subsequent exfoliation.

Cutting Pliers or Bone-nippers (sometimes known as Liston's forceps) are used in amputations for the purpose of removing any rough or splintered edges left by the saw, or, in operations on the hands or feet for dividing the phalanges or the bones of the metacarpus or metatarsus. The whole length of the instrument may be from ten to twelve inches (Fig. 128), of which not

Fig. 128.

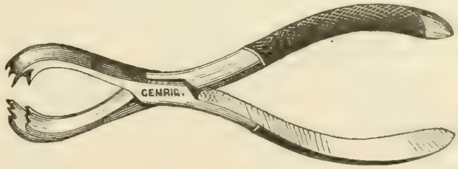


Liston's cutting bone forceps.

more than two inches should be occupied by the blades. The latter should be sharp, and may conveniently be set at an obtuse angle to the handles, which should be very strong and roughened, so as to obviate any danger of the hand slipping.

Strong Forceps for holding a projecting extremity of bone are useful in cases in which amputation is rendered necessary by avulsion of a limb, or by

Fig. 129.

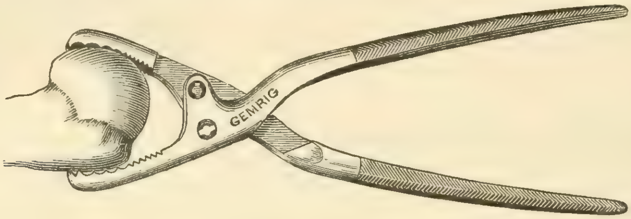


Fergusson's lion-jawed forceps.

a compound fracture in which the injury of the soft-tissues is so extensive that the assistant charged with steadying the part to be removed, cannot

obtain a firm grasp; often, too, particularly in the circular operation, after the vessels have been secured and the tourniquet removed, it may be thought desirable to take away an additional segment of bone, and then it will greatly facilitate the surgeon's manipulations with the saw, if an assistant holds the projecting end of bone with strong forceps. An excellent instrument for this purpose is the "lion-jawed" forceps of Sir William Fergusson (Fig. 129). Another, still more powerful form of instrument, which bears the name of Farabeuf, is shown in Fig. 130.

Fig. 130.



Farabeuf's forceps.

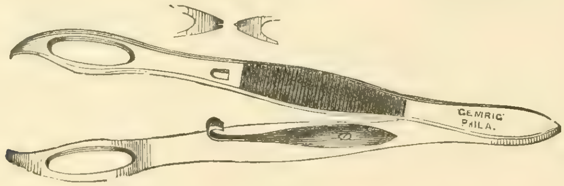
Artery Forceps and Tenacula are employed to take up the cut arteries (and veins, too, if they bleed), preparatory to tying them. The best form of

Fig. 131.

Cross-spring forceps.

forceps is that shown in Fig. 131, the blades crossing, and being kept shut by their own spring; the blades themselves should be expanded a little way

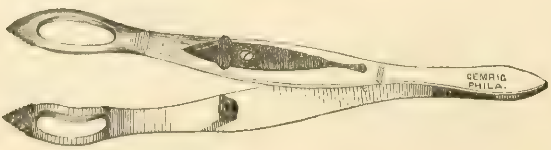
Fig. 132



Catch forceps.

above the points, so that when the ligature is applied it may readily slip down without including the ends of the instrument itself in the knot. Other

Fig. 133.



Slide forceps.

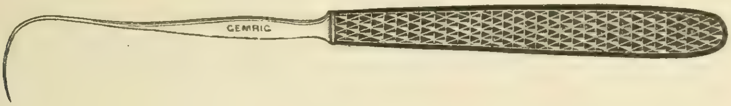
varieties of forceps are made to fasten with a catch (Fig. 132), or with a slide (Fig. 133), but the spring forceps are much the best. All of these varieties

are included under the generic name of the "bull-dog" forceps, the invention of which is attributed to the late Mr. Liston.

Dr. Hodgen, of St. Louis, has devised an ingenious form of artery forceps by which the vessel is drawn from its sheath by the weight of the instrument, a cutting slide serving afterwards to divide the ligature, and thus enabling the operator to tie the artery without the help of an assistant.

The *tenaculum*, or sharp hook (Fig. 134) is, upon the whole, not so convenient an instrument as the forceps, though invaluable in certain cases, as

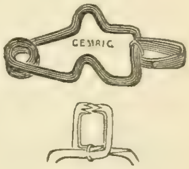
Fig. 134.



Tenaculum.

when the parts are matted together by inflammatory action of long-standing, so that the vessels cannot be readily seized by the forceps, or when an artery bleeds in close proximity to the bone. In some cases it is even necessary to take up a mass of tissue, including the vessel, with *two tenacula*, and throw a ligature around the whole, withdrawing the second tenaculum before the knot is finally tightened. Though I have very often practised this *ligature en masse*, and have never seen any evil consequence result from it, yet it is better when practicable to draw each vessel a little way from its sheath, and tie it separately. The tenaculum should be of sufficient size—an inch to an inch and a quarter in the transverse portion of the hook—and not too much curved.

Fig. 135.

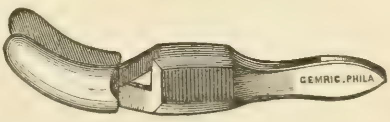


Serre-fines.

Besides the artery forceps which have been described, the surgeon will do well to have in readiness some *serre-fines* (Fig. 135) and *spring-clips* (Figs. 136, 137), which are known here by the name of the late Mr. Nunneley. These are particularly convenient in case, after the removal of the tourniquet, several points should be seen bleeding simultaneously. These clips can be quickly applied, so as to control the hemorrhage temporarily, and then removed one by one as the surgeon is ready to supply their place by ligatures.

Fig. 136.

Fig. 137.

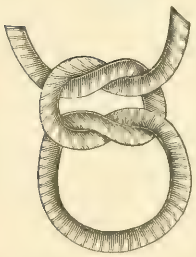


Nunneley's clips.

Ligatures may be made from a great variety of materials, such as catgut, horsehair, or other animal substances, silver or iron wire, or, which I much prefer, fine whip-cord or strong silk. *Animal ligatures* were employed by Sir Astley Cooper and by Dr. Physick, and in the form of the *carbolized catgut ligature* have been revived by Prof. Lister and his followers, and are habitually used by those surgeons who employ the so-called "antiseptic method." The late Prof. Eve, of Nashville, thought highly of a ligature made from the *sinew of the deer*, and Mr. Barwell has employed ligatures from the middle coat of the *aorta of the ox*, and Mr. T. Smith and Mr. Croft those from the *tendon of a kangaroo*. *Metallic ligatures* were used, about fifty years ago, in a number of experiments on the lower animals by Dr. Levert, of Alabama,

and similar experiments have been since repeated by Sir J. Y. Simpson and by Dr. B. Howard, of New York. While both animal and metallic ligatures have been employed in operations upon the human subject with sufficient frequency to leave no doubt as to their safety and efficiency, I have seen no evidence to make me think them in any way better than the hempen or silken ligatures which are more generally employed. Indeed silk (which, however, is itself an animal substance) seems to me, upon the whole, the best material from which a ligature can be made. It can be carbolized, if the surgeon wish, and in this form was at one time used by Prof. Lister, and was preferred to catgut by the late Mr. Maunder. Silk is now prepared for the surgeon's use by *plaiting* the strands instead of *twisting* them, and the plaited ligature has the advantage of much greater strength as well as of greater readiness in application. Silk ligatures should be about eighteen inches in length, the ordinary skein of silk which contains about six yards thus sufficing for twelve ligatures. Before using the silk, it should be well waxed, that the ligatures may not become entangled with each other, and that they may not slip in the surgeon's hands. In applying a ligature, the bleeding vessel is caught and drawn a little forward with either the artery forceps or the tenaculum, and an assistant then throws the thread around it and secures it with a double knot. The ligature should be tightened by a firm and steady pull, without any jerking movement; the first knot should be made with sufficient force to divide the inner and middle coats of the artery, and the second knot adjusted so as to prevent the first from slipping; if catgut or horsehair be employed, a third knot is desirable. The best form of knot is that known by sailors as the "reef-knot" (Fig. 138); it is much to be preferred to either the "granny" (Fig. 140) or the "surgeon's knot" (Fig. 139).

Fig. 138.

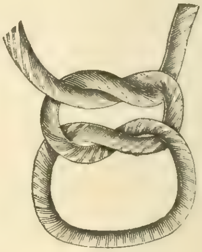


The "reef" or "sailor's" knot.

Fig. 139.

The "surgeon's" knot.

Fig. 140.



The "granny" knot.

It is customary, when many ligatures are applied, to cut off one end of each and bring the other end out at any convenient part—usually one angle—of the wound. For purposes of distinction, both ends of the ligature which surrounds the main artery may be left and knotted together. It has been proposed to bring each ligature out separately by an independent opening through the covering of the stump, so as to allow the edges of the wound to come in contact throughout their whole extent, without interruption; but apart from the inconvenience and delay which would be caused by such a mode of procedure, the ligature ends themselves, being brought out in one or two groups, serve a useful purpose by affording an excellent means of drainage. *Short-cut ligatures*—that is, with both ends cut short—were much employed by Hennen and a few other surgeons in the early part of this century, and have been revived in connection with the "antiseptic method" by Prof. Lister and his followers. If short-cut ligatures are used, a perforated, India-rubber drainage tube must be employed to allow the escape of the

fluids which are always poured out in an amputation-wound after the operation, but if the ordinary form of ligature be adopted, the drainage tube is usually unnecessary. Other means of checking the bleeding after amputation, such as *acupressure* or some of its modifications—filo-pressure, etc.—or *torsion*, may be employed, and each method is advocated by excellent surgeons. These will be fully described in the article on Injuries of Blood-vessels, in a subsequent volume, and need not be further considered here. I have, however, no hesitation in expressing the opinion that the ligature is more valuable than all of its substitutes put together, and is certainly preferable as a means of arresting hemorrage after the operation of amputation.

The Retractor is an important part of the necessary apparatus for an amputation, and its value, as has been already mentioned, was fully recognized by the surgeons of antiquity. It consists of a piece of stout muslin, six or eight inches wide and three or four feet long, one end being split to the middle into two tails for amputations of the upper arm and thigh, and into three tails for those of the forearm and leg below the knee. In the former case the tails are wound around the bone, and crossed; in the latter, the middle tail is thrust between the bones and the others are disposed of as before; both ends of the retractor are then grasped by an assistant and firmly drawn upwards, so as to answer the double purpose of retracting the muscles from the bone and of protecting the soft parts from being injured by the saw. The muslin retractor is made fresh for every case; certainly a cleaner and better plan than to use the leather retractor of Gooch,[1] Bromfeild,[2] and others of our predecessors.

Sutures.—Great diversity of opinion has prevailed at different times as to the propriety of using *sutures* in the dressing of amputation wounds. The ancients employed them as one of the means of arresting hemorrhage, and they continued to be thus used until the general adoption of the ligature; and the eminent surgeon of Guy's Hospital, Samuel Sharp, or Sharpe—he spelt his name both ways—revived the use of the "cross-stitch" (an old device employed by Paré and Wiseman), to prevent retraction of the soft parts and consequent protrusion of the bone, and in both his "Treatise on the Operations of Surgery," and his "Critical Enquiry," lauded it as not less valuable for this purpose than the "double incision" of Petit and Cheselden. Other surgeons have reprobated the use of sutures altogether, preferring to secure approximation of the edges of the wound by the use of compresses and bandages, or by the employment of adhesive plaster. There can certainly be nothing more injudicious than to sew up a stump tightly, as if to hermetically seal it, without making any provision for the escape of effused fluids, or allowing for the unavoidable occurrence of swelling; such a mode of dressing the wound will, in the course of a few hours, probably send up the patient's pulse and temperature in an early development of traumatic fever, and it will be fortunate if the mistake is discovered in time to cut out the offending stitches before sloughing is inevitable. But provided that there is tissue enough to cover the bone without making tension, and that ample drainage is afforded either by the ligature ends or by the introduction of a tube, sutures may be properly employed after amputation, and present, I think, many advantages over other methods of closing the wound.

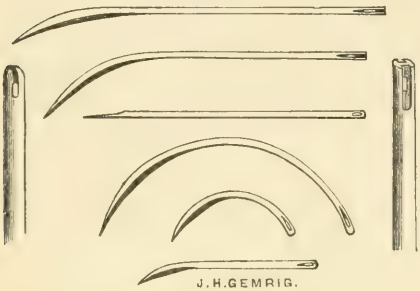
The best *material* for the suture is, I think, silver, lead, or malleable iron wire; catgut is unsatisfactory, as not keeping its place for a sufficient length

[1] Cases and Practical Remarks in Surgery, vol. ii. p. 330. Norwich, 1767.
[2] Chirurgical Observations and Cases, vol. i. p. 152. London, 1773.

of time, while the metallic has the great advantage over the silk or hemp suture, that it can be loosened by untwisting, if there be too much tension of the part, without being entirely withdrawn. Indeed I make a practice, at the first renewal of the dressing after an amputation, of trying every suture point in succession, and untwisting it a little, if it seems to be applied too closely. The *form* of suture adapted for amputation wounds is the *interrupted suture*, and its points should be at least half or three-quarters of an inch apart. If silk be employed, it is tied in a reef-knot (as in the case of ligatures), but if wire be used, it is twisted with four or five turns, and the ends then cut smoothly off; it is well to take the precaution of twisting all the stitches in the same direction, for greater convenience in untwisting if this should be found necessary.

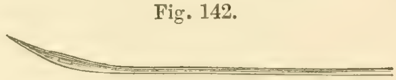
Needles.—The ordinary "surgeon's needle" (Fig. 141) answers every purpose in introducing the sutures after amputation, whatever material for the suture be employed. The needle should be rather large, strong, and either straight or but slightly curved. It should be provided with a lance-point, that it may readily penetrate the tissues, and should have a large eye that it may be threaded without difficulty. Needles are made, to be used with wire, with a groove on either side at the eyed end; but the wire very seldom rests in the groove, and the advantage of this modification is more in theory than in reality. Other needles have been made with a female screw worked in the blunt end, for the wire to be screwed into it; but the wire is apt to become detached at inconvenient moments, and upon the whole I am disposed to regard the old-fashioned needle as quite as satisfactory as any of its substitutes. If the flaps be unusually thick, it may be convenient to employ a needle with a handle, and an eye near its point (Fig. 142), like that employed in the operation of strangulating a nævus. The wire with which a needle is armed should be about eighteen inches long, and should be passed through the eye for an inch or an inch and a quarter of its length, and then folded evenly upon itself, *without twisting;* its thickness should be in proportion to the size and weight of the flaps which it is intended to hold together, and it should be flexible and smooth, and quite free from kinks.

Fig. 141.



Various forms of needle.

Fig. 142.



Needle with eye near point.

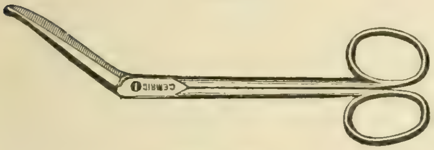
Fig. 143.

Dissecting forceps.

Dissecting Forceps (Fig. 143) are employed to seize projecting nerves or tendons which may require to be cut off, and to aid in adjusting the sutures.

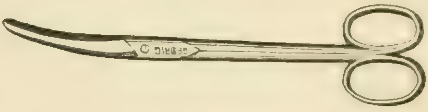
SCISSORS of various sizes and shapes are used in an amputation. There should be one pair, strong, and with blades set at an angle (Fig. 144), for cutting plasters and bandages; a pair of ordinary "surgical scissors," sharp

Fig. 144.



Bandage scissors.

Fig. 145.



Scissors curved on the flat.

and strong, for cutting ligatures and sutures; and a third pair, with blades curved on the flat (Fig. 145), also sharp and strong, for retrenching protruding nerves, tendons, and masses of fascia.

Besides the various instruments required for an amputation, and the necessary dressings, the surgeon should see that there are in readiness plenty of clean sponges of a convenient size; warm and cold water; a hot-water can, or spirit-lamp, for heating strips of adhesive plaster, if the ordinary officinal plaster is to be employed—what is sold as the "American Surgeons' adhesive plaster," though somewhat more expensive, is a more convenient article, adhering without being warmed; an efficient styptic for controlling capillary hemorrhage; and a little white wax for plugging the medullary cavity of the bone, if that should be the source of troublesome bleeding.

OPERATIVE METHODS EMPLOYED IN AMPUTATION.

All the various methods of amputating may, as heretofore mentioned, be regarded simply as modifications of the two principal modes already referred to, the flap and the circular. Thus the oval operation, as perfected by Scoutetten and Malgaigne, is a variety of the circular method, while the different plans of Sédillot, Teale, Lee, Stephen Smith, etc., may all be considered as modifications of the flap operation.

CIRCULAR METHOD.—M. Fort, one of the most recent French writers on operative surgery, enumerates no less than seven varieties of the circular operation, distinguishing them as the procedures of Alanson, Benjamin Bell, Brunninghausen, Desault, Louis, Malgaigne,[1] and J. L. Petit. The peculiarities of most of these methods have been sufficiently indicated in the section devoted to the History of Amputation,[2] and I may add here that the special feature of Brunninghausen's plan consisted in dissecting up a cuff of skin, as done by Hey, Bell, and Alanson, and then cutting the muscles and bone on the same plane, and that of Malgaigne's operation in combining the peculiarities of both Desault's and Bell's methods, making thus what he called a "quadruple incision."[3] The circular operation, as ordinarily practised at the present day, is in all essential particulars the operation of Hey, Bell, and Alanson, and is performed as follows:—

The part to be operated upon having been washed and shaved, and the patient being thoroughly under the influence of an anæsthetic, he is brought

[1] Malgaigne himself enumerated *nine* methods, exclusive of his own.
[2] Vide supra, pp. 557, 558.
[3] Manuel de médecine opératoire, 3e édit. p. 290. Paris, 1840.

to the side or foot of the bed or operating table, in such a way that the limb to be removed shall project fairly over the edge. The patient should be well protected from the cold, and a coarse blanket, or a tray containing bran or saw-dust, should be placed on the floor to catch the blood. The circulation is then to be controlled by the adjustment of the tourniquet with or without Esmarch's tube, as already described, or in certain situations by the pressure of an assistant's finger, or by means of a wrapped key, as will be particularly explained when we come to speak of amputations at the shoulder. If the application of the tourniquet is entrusted to an assistant, the surgeon should at least see for himself that the compress is accurately placed over the main vessel, and that the strap is drawn sufficiently tight for the pulsation of the artery below to be arrested by a few turns of the screw. The circulation being under control, one assistant is deputed to take special charge of the tourniquet, a second to manage the anæsthetic, and a third to hold the limb in whatever position may be convenient for the operator. A fourth assistant may hand the instruments, or, which I prefer, these may be arranged in a tray at the surgeon's right hand, in the order in which they are to be used, so that he may readily help himself. The operator should stand with his *left* hand towards the patient's trunk; thus in amputating the *right* lower extremity, the surgeon stands at the patient's right side, while in removing the *left* leg or thigh he stands between the patient's limbs. In amputating the *right* arm, he stands facing the patient's feet; but in amputating the *left* arm, he faces the patient's head.

Almost all of the older surgeons, beside the fillet or band with which they tried to control the circulation, before the invention of the tourniquet, applied other bands, one above and one below the point at which the limb was to be removed; these were to serve the triple purpose of numbing the patient's sensibility, of preventing the muscles from slipping or being jerked away from the knife, and of furnishing a guide for the surgeon's incision. But, as Bichat[1] very justly observed, with a good eye and a sharp knife (and every surgeon should possess both of these), such clumsy helps to the operation are quite unnecessary.

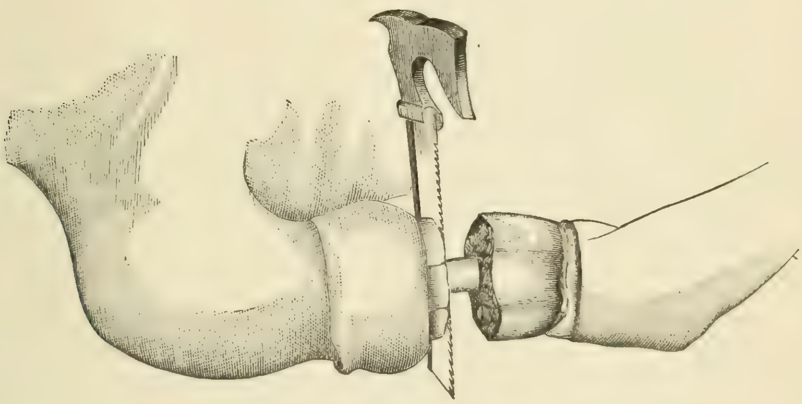
In making his first incision, the surgeon should steady and draw the skin of the patient's limb upwards with his left hand, while, stooping somewhat, he carries his right hand, holding the long knife, around the limb, so that the back of the knife shall be directed towards his own face. Sinking the heel of the knife then firmly into the flesh, he makes a circular sweep around the part, rising as he does so, and thus completes the whole, or nearly the whole, of the cutaneous incision with one motion. A few light touches with the same knife, or with a scalpel, serve to free any points at which the skin may be still adherent, and permit considerable retraction to be at once effected. If the limb be slender, this degree of retraction may be sufficient, but it is usually necessary to dissect up, by rapid strokes of the knife, a cuff of skin and fascia, about half as long as the limb is thick. The first incision should go completely down to the muscles, and, in dissecting up the cuff, the edge of the knife should be kept constantly directed towards the deeper structures, as otherwise the nutritive vessels of the skin will be endangered, and sloughing will be apt to follow. If the limb be conical (as in the calf of the leg), there will be great difficulty in reflecting the dissected cuff, and the surgeon will then find advantage in making a longitudinal incision on one or the other side—a modification of the ordinary procedure which Sédillot[2] attributes to Lacauchie. This incision supplies a convenient point for bringing out the

[1] Œuvres chirurgicales de P. J. Desault. Seconde partie, p. 490. Paris, 1798.
[2] Traité de médecine opératoire, tome i. p. 322. Paris, 1853.

ligatures, and, if it be made in a somewhat dependent position, serves also as an excellent avenue for drainage. When the skin cuff has been evenly dissected back to a sufficient height, the surgeon again applies the long knife, as before, and cuts through the muscles quite down to the bone. A wide gap is instantly produced by the retraction of the divided muscles, but it still remains to sever their attachments to the periosteum, and to push them upwards, either with the finger or the handle of the scalpel, so as to leave the bone bare for the extent of about two inches. If the limb contain two bones, the interosseous tissues are divided with the scalpel, or with a narrow, double-edged catlin, and the adjoining surfaces of the bones cleared in the way already described.

The retractor is next adjusted—its middle tail, in the case of the forearm or leg, being thrust between the bones with the finger, the handle of a knife, or a pair of forceps—its body carefully spread out over the soft parts, its tails crossed, and the whole firmly drawn upwards by an assistant. The next step is the sawing of the bone, which is to be done at the highest point at which this has been exposed. (Fig. 146.) Some writers lay great stress upon the

Fig. 146.



Amputation of arm by circular method.

importance of dividing the periosteum with the knife, before applying the saw; but I must confess to a belief that in practice this is more often talked about than done. Tho saw should be held lightly at first, and drawn backwards (from heel to point) so as to make a groove for itself, and thus avoid splintering the bone; if there are two bones, they are, usually, divided simultaneously, or, if this cannot conveniently be done, the smaller before the larger. Roux and Malgaigne advise, however, and I think with reason, that, in the case of the leg, the tibia should be divided first, and then the fibula at a point about half an inch higher. It is usually directed that the saw should be held vertically, so that the bone may not be broken through by the weight of the limb before its section has been completed. For the same purpose, the assistant who has charge of the limb should hold it up firmly and not allow it to drop, but at the same time should not elevate it so much as to make the saw bind.

As soon as the limb is off, the surgeon turns his attention to the cut vessels, taking up first with forceps or tenaculum the principal arteries, and afterwards securing the muscular and other small branches, loosening the tourniquet for a moment, if necessary, that the gush of blood may indicate their position. If, as I have advised, the Esmarch tube be used in addition

to the tourniquet, the latter should be screwed down, and the former removed, as soon as the principal vessels have been ligated. Some difference of opinion exists among surgeons as to the advisability of tying *veins* after an amputation; while not often necessary, it is so occasionally, for large veins will sometimes bleed profusely even after the removal of the tourniquet; and the risk of phlebitis and pyæmia which was formerly supposed to be incurred by tying a vein, has been over and over again shown to be purely imaginary. My own practice is to tie them, often indeed including the artery and its *venæ comites* in the same ligature, or, in the case of such a large vessel as the brachial or the femoral, tying the artery first separately, and then throwing a second ligature around it and the vein together. The surgeon having secured all the vessels that can be found bleeding, the surface of the stump may be washed with a styptic, in order to check any capillary oozing which may still persist; various substances may be used for this purpose, such as the "Aqua Pagliari," or the "Aqua Binelli"—the former containing benzoin and alum,[1] and the latter no less than twenty-six different astringents or aromatics of vegetable origin[2]—or, which is as efficient and at least as convenient as any other, simple diluted alcohol.

Before closing the wound, the surgeon examines the sawn end of the bone, and, if any projecting spicula has been left, cuts it off with the pliers; he also retrenches any tendons or nerves that hang from the end of the stump, by drawing them out with the ordinary dissecting forceps, and snipping them off with scissors curved on the flat. If bleeding proceed from the bone itself, it may be most conveniently arrested by arming a pellet of softened white wax[3] with a wire (to facilitate withdrawal), and then pressing it firmly against the bone so as to plug its medullary cavity; the wax may be removed at the first or second dressing of the stump, coming away without difficulty alongside of the ligatures. If a vessel in the periosteum bleed, and cannot be tied, it may be secured by acupressure, applied either by the Aberdeen or "twist" method, or by the third method of Sir J. Y. Simpson.

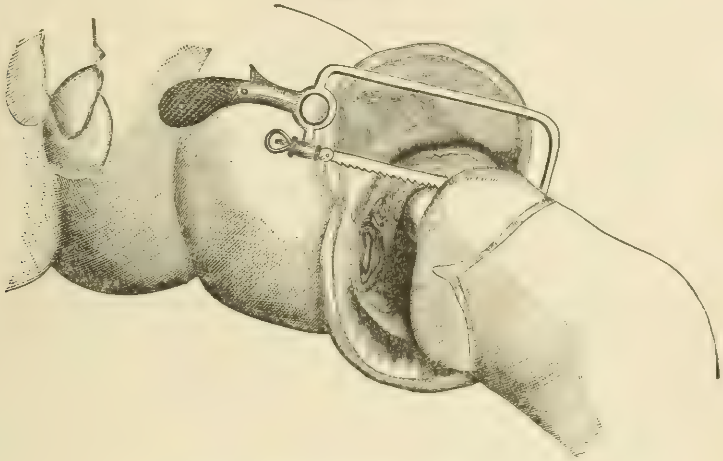
The stump being at length dry, the ligatures are disentangled from each other, and brought out in one or more bundles as may be found convenient. The skin cuff is then drawn down over the face of the stump, and the wound is closed with sutures, converting the circular into a linear incision, and in any direction which the operator may prefer—horizontal, oblique, or vertical—it makes very little if any difference which be chosen.

Modified Circular Operation.—This mode of amputation (Fig. 147), which affords an excellent stump, appears to have been suggested more than forty years ago by the late Mr. Liston,[4] and was, with an important modification, extensively practised afterwards by the late Mr. Syme.[5] Liston's plan was to make two semilunar flaps of integument only, divide the muscles by a circular incision where the skin flaps joined, and saw the bone as in the ordinary circular method; Syme's modification consisted in dissecting up a cuff of skin for some distance above the point of junction of the semilunar flaps. In either form the procedure may be looked upon as an ordinary circular operation, in which the cuff of skin has been slit upon both sides, and the angles trimmed off. It is particularly adapted for operations on muscular

[1] Bulletin de Thérapeutique, t. xlii., and Sédillot, op. cit. p. 218.
[2] Bouchardat, Annuaire de Thérapeutique pour 1843, p. 227.
[3] Riedinger prefers a plug of catgut, while others employ a pledget of lint or a plug of wood. Wax, however, seems to me to be the best material.
[4] Elements of Surgery (1840), edited by Prof. S. D. Gross, p. 642. Philadelphia, 1846.
[5] Principles of Surgery, 4th edition, pp. 148, 149. London, 1856.

limbs, where it fully merits Mr. Skey's[1] encomium, that it "is really a good operation," and I prefer it to any other for amputations at or above the middle of the thigh.

Fig. 147.



Amputation of thigh by modified circular method.

Elliptical Operation.—This, which is often spoken of as a variety of the oval method, and, on the other hand, as a modification of the operation by a single flap, is attributed by Sédillot, Guérin, and other French writers on Operative Surgery, to a Belgian surgeon, Soupart, of Liège, but was practised

Fig. 148.

Amputation at elbow by elliptical method.

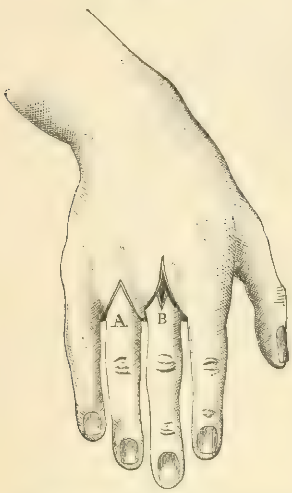
as an improvement on the circular method, in amputations below the knee, by Sharpe,[2] of Guy's Hospital, in the middle of the last century. It is particularly adapted to amputations at the knee- and elbow-joints, and especially the latter. (Fig. 148.) The incision constitutes a perfect ellipse, coming below the joint, on the least vascular side, by a space equal to the diameter of the limb, and the resulting flap being folded upon itself, so as to make a short

[1] Operative Surgery, page 309. Philadelphia, 1851.
[2] Treatise on the Operations of Surgery, page 226. Ninth edition. London, 1769.

curved cicatrix on the side of the vessels, thus making an excellent, non-adherent covering for the bone.

Oval Operation.—The *oval operation*, or that of Scoutetten, may be regarded as a modification of the circular method, the skin cuff being slit upon one side, and the corners trimmed off. Occasionally practised in the latter part of the last and at the beginning of this century, by Lassus, Larrey, Guthrie, and other surgeons, this mode of amputating was first reduced to a system by Scoutetten, of Lille, in 1827.[1] We may recognize two sub-varieties of this operation (Fig. 149):—

Fig. 149.



Amputation of fingers by oval method. A, method of Scoutetten; B, method of Malgaigne (*en raquette*).

(1) *Method of Scoutetten.*—In this (Fig. 149, A), an incision is begun on the outer side of the limb, and carried obliquely downwards for a distance about equal to its diameter; then continued transversely across the inner side of the limb (or that which contains the great vessels), and obliquely upwards again to meet the first incision at an acute angle. Or the same object may be accomplished by making first two oblique incisions, resembling an inverted Λ, and joining them below by a transverse cut.

(2) *Method of Malgaigne.*—This (Fig. 149, B), which is called by French writers the operation *en raquette*, from the "racket-shaped" form of the wound, is preferable as affording a better covering for the bone at the upper part of the incision. Malgaigne particularly recommended this operation for amputation of the thumb, but it is equally applicable to other parts; it consists in making a longitudinal incision on the outer side of the limb, extending a short distance above and twice as far below the point at which it is intended to amputate; the lateral branches of the oval incision are made to start from the junction of the middle and lower third of the longitudinal incision.

In both of these varieties of the oval method, the wound is brought together in a *longitudinal* direction, the operation herein differing widely from the elliptical method described above, in which the resulting cicatrix is a *transverse* one.

Single Flap Operation.—This was the original method of Lowdham, and, as improved by Verduin and Garengeot, may still be occasionally resorted to with advantage. In most cases, no doubt, either the double flap or the circular operation, or one of the modifications of the latter which have already been referred to, will enable the surgeon to obtain sufficient covering for the bone while dividing it at a lower point than could be done were the flap to be taken altogether from one side; but it may well happen, in a case of compound fracture or laceration, from violence by railway or machinery, or in a case of incurable ulcer from burn, frost-bite, etc., that the tissues on one side of a limb may be so injured or diseased that they must be inevitably sacrificed, while those on the other side are perfectly healthy, and ample in extent to furnish a good covering after amputation; under such circumstances, the

[1] Velpeau, op. cit., tome ii. p. 364. According to Lisfranc (op. cit., tome i. p. 744), who always liked to differ from Velpeau, the oval operation originated with Le Dran; but I can find no account of it in my copy of the latter author's work (Paris, 1742).

surgeon should take his flap from the sound part exclusively, and will thus probably be enabled to preserve a greater length of the affected limb than he could in any other way. The circulation being controlled in the ordinary manner, the surgeon, with a strong and rather short knife, begins his incision on the lower surface (so that the path of his knife may not be obscured by the flow of venous blood), and marks out a tolerably square, or at least *not a pointed*, flap, which should embrace, beside the skin and fascia, part or all of the subjacent muscular layers, according to the thickness of the part. This flap is rapidly dissected up, and the section of the soft parts completed by making a transverse or slightly curved incision, convex forwards, through the tissues on the other side of the limb. The bone is next cleaned by a few touches of the knife, the muscles pushed upwards and the retractor adjusted, and the amputation then completed as in the circular method. The single flap operation may also be done by transfixing the limb with a long knife, and cutting from within outwards; but the flap can be better shaped by pursuing the other plan, and where there is no superabundance of available tissue, as in the cases which I have supposed, it will certainly be preferable. The single flap operation is thought by Prof. Spence, of Edinburgh, to be in most cases preferable to any other. It is also employed by Carden, of Worcester, and by Wharton, of Dublin.

Double Flap Operation.—Of this method we may recognize several varieties, as Ravaton's, Vermale's, Sédillot's, Langenbeck's, Teale's, and Lister's.

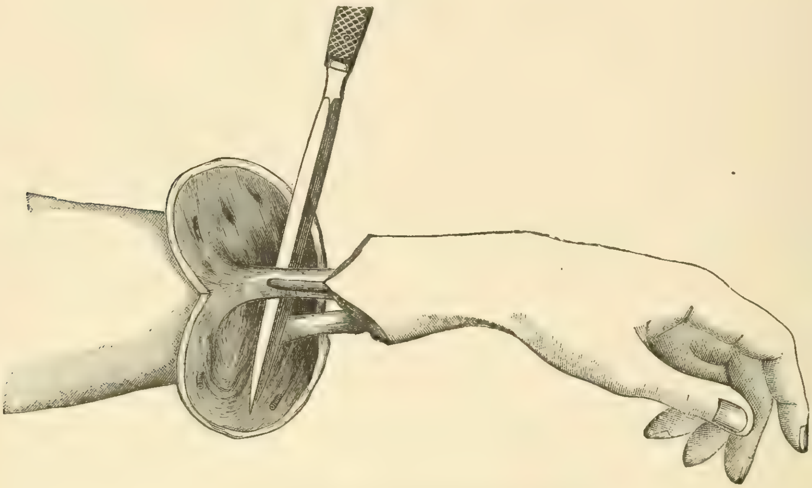
(1) *Ravaton's method* consists in making a circular incision down to the bone, and then adding a longitudinal incision on either side, so as to make two flaps, each half the thickness of the limb. In this form, the operation is seldom if ever resorted to at the present day, the flaps being unwieldy, and the protruding muscles causing an undesirable degree of tension when they are brought together.

(2) *Vermale's method* is the ordinary double-flap operation of modern times. In employing this mode of amputating, most writers, following Liston,[1] advise that the surgeon should stand with his left hand towards the part to be removed; my own practice, however, has been to adopt the same position as that which I have recommended for the circular operation, entrusting the entire care of the limb to an assistant, and keeping the left hand towards the patient's trunk, ready to grasp the artery if by any chance the tourniquet should slip. This plan is in accordance with the advice of Malgaigne,[2] and I feel sure that it will be found the most satisfactory. The patient having been prepared for the operation in the way described when speaking of the circular method, the surgeon with his left hand grasps and slightly raises the tissues of which the flap is to be formed, and then, keeping (as advised by Lisfranc)[3] his right elbow close to his body, introduces the long pointed knife at the side of the limb which is nearest to himself; then pushing it around and across the bone with a firm but gentle movement, and somewhat elevating the handle of the instrument after the point has passed the bone, he completes the transfixion of the limb by bringing the knife out at a point diametrically opposite to that at which it entered. Keeping the blade now in a plane corresponding to the long axis of the limb, he forms his first flap by cutting with a rapid sawing motion, at first in a longitudinal direction, and then obliquely towards the surface. The flap thus made, which should have a

[1] Op. cit., p. 637. [2] Op. cit., p. 295.
[3] Précis de Médecine opératoire, tome i. p. 737. Paris, 1845.

length of at least half the diameter of the limb, is then turned back and entrusted to an assistant, while the surgeon re-enters his knife at the point of original puncture (this time passing on the other side of the bone), brings it out as before, and cuts the second flap, which in shape and size should be as closely symmetrical as possible to that first formed. (Fig. 150.) The retractor is next adjusted; any remaining fibres divided by a few touches of the knife; and the bone sawn as in the circular operation.

Fig. 150.



Amputation of forearm by double-flap method.

If the flaps are made antero-posteriorly, the anterior flap is usually formed first; if lateral flaps are preferred, the outer should be made before the inner. The general rule is that that flap should be last cut which contains the principal artery.

(3) *Sédillot's method*, which that author describes as a "mixed procedure,"[1] differs from Vermale's, in that the surgeon, instead of making his knife "hug" the bone, keeps the instrument away from it in transfixing the limb, so as to include but a small portion of muscular tissue in each flap; the remaining muscles, together with the great vessels, are then divided by a circular incision, and the rest of the amputation completed as in the ordinary circular method. The flaps are somewhat shorter, as well as thinner, than those of Vermale's operation, which is certainly an advantage if the limb be a very large one. I have, in amputating the thigh, sometimes varied Sédillot's procedure by cutting superficial flaps from without inwards, as in Langenbeck's method, and then completing the operation by a circular sweep of the knife, in the ordinary way. The stump which results from Sédillot's plan of operating, closely resembles that obtained by the *modified circular* method, over which it does not appear to me to present any marked superiority.

Some surgeons, having regard to the gradual atrophy of muscular tissue which always occurs in a stump, attempt to save, as they think, time and trouble, by making their flaps from skin only; but not only is there considerable risk of the flaps sloughing, under these circumstances, but the stump thus obtained is less serviceable than when the flaps contain muscle also; for

[1] Op. cit., tome i. p. 331.

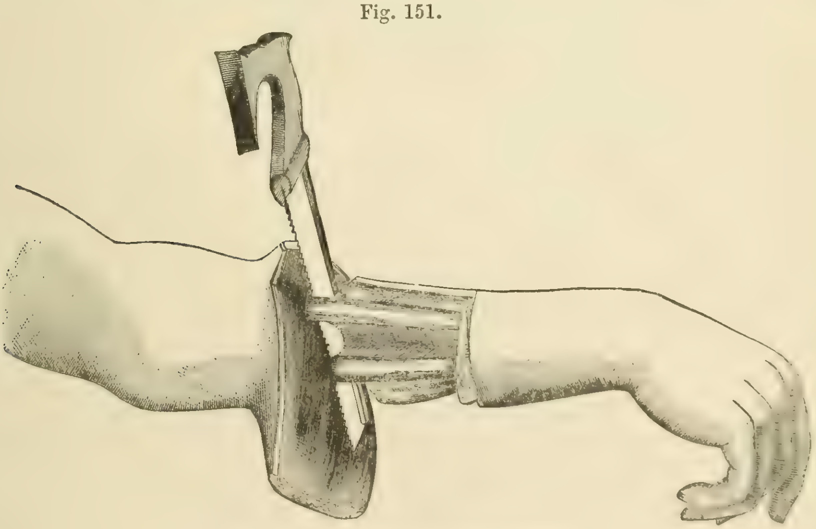
although it is a fact that the true muscular substance gradually disappears from a stump, the fibrous sheaths of the muscles remain, and, becoming condensed into a thick and resisting mass, form a useful pad for protecting the sawn extremity of the bone.

(4) *Langenbeck's method*, which has already been incidentally mentioned, consists in cutting double flaps from without inwards. This plan presents the advantage of enabling the surgeon to shape his flaps more accurately, and to better insure their symmetry, than when they are formed by transfixion. In making antero-posterior flaps by this method, the posterior flap, contrary to the rule before given, should be cut first; the reason for this is that if the hinder flap were left to be formed last, the line of incision would be obscured by the blood flowing from the anterior portion of the wound.

Langenbeck's method may sometimes be advantageously combined with Vermale's, one flap being cut from within outwards, and the other by transfixion; in some localities, as the leg, this is the plan ordinarily adopted, the subcutaneous position of the tibia rendering it very difficult to cut an anterior flap here except in this way. This combination-flap method is also very well adapted for amputations of the thigh just above the knee. Another combination of these two methods was practised by Dupuytren and Larrey, who cut through the skin from without inwards, and then completed their flaps by transfixion.[1]

(5) *Teale's Method, or Amputation by a Long and a Short Rectangular Flap.*—This mode of operating, which unquestionably affords a most admirable stump, was first practised by its inventor, the late Mr. Teale, of Leeds, in June, 1855.[2] There are two flaps cut from without inwards, as in Langen-

Fig. 151.



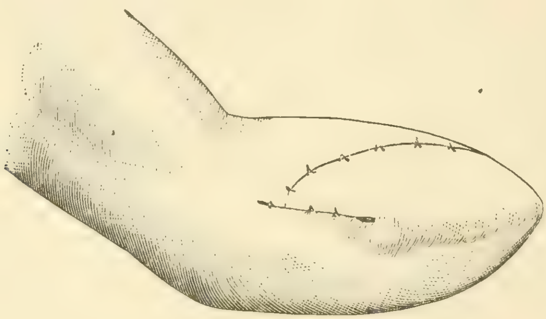
Amputation of forearm by Teale's method.

beck's method, but with the peculiarity that they are rectangular, and that while they are equally wide, one is just four times as long as the other (Fig. 151). The long flap is taken from the side of the limb on which there is

[1] Lisfranc, op. cit., tome i. p. 733.
[2] On Amputation by a Long and a Short Rectangular Flap. By Thomas P. Teale, F.L.S., F.R.C.S., etc., page 13. London, 1858.

least muscular tissue, and which does not contain the principal vessels; both flaps include all the structures down to the bone. The surgeon begins by ascertaining, with a piece of string or tape-measure, the *circumference* of the limb at the point at which it is to be removed; *half* of this circumference gives the dimensions in each direction of the long flap, which must represent a perfect square. This flap having been marked out upon the limb with ink or crayon, the dimensions of the short flap are similarly indicated, its width being likewise *half the circumference* of the limb, but its length only *one-eighth*, or *one-fourth the length of the long flap.* It is very important that the flaps should be accurately marked out upon the limb before beginning the operation, as otherwise, when taken from a conical limb, the long flap will almost certainly be cut narrower at its extremity than at its base. The long flap is cut first, with a strong, short knife; turned up, and given in charge to an assistant; the short flap being made, the retractor is applied, and the rest of the operation completed as in the circular method. In closing a "Teale stump" with sutures, the ends of the flaps must be first brought together, and the lateral wounds sewed up subsequently. (Fig. 152.)

Fig. 152.



Stump resulting from amputation by Teale's method.

The advantage of this mode of amputating is that it furnishes a firm cushion of soft tissues to cover the end of the bone, and that it allows the cicatrix to be entirely withdrawn from pressure in the adjustment of an artificial limb; its disadvantage is that, when the limb is a large one, the peculiar form of the flaps requires the bone to be sawn at a much higher point than would otherwise be requisite, and thus not only gives a very short stump, but, at least in the case of the thigh, considerably enhances the danger of the operation. Thus, in a case of injury, should the laceration of the soft parts extend as high as the patella, and the thigh be six inches in diameter —not by any means an excessive measurement—the long flap would have to be nine inches square (half the circumference), and the bone, instead of being divided in its lower third, as it would be in the circular or the ordinary double-flap operation, would be sawn above its middle, and the risk to the patient thus materially increased.

In order to obviate this disadvantage of Teale's method, the next plan to be described was suggested about twenty years ago by Prof. Lister, then of Glasgow, but now of King's College, London.

(6) *Lister's Method.*—This mode of amputating was originally recommended by its distinguished author for operations in the thigh and leg only, but it is equally applicable, as I have found by experience, in other situations also. Lister's operation may be described as something midway between that of Teale and the old operation of Ravaton. In the latter, as will be remem-

bered, the flaps were rectangular, and of equal length; in Teale's operation, they are likewise rectangular, but the outer or anterior flap is four times as long as the other. Prof. Lister's suggestion is that the flaps shall be so proportioned that the line of cicatrix shall come just beyond the edge of the bone, while this can be left considerably longer than in the Teale operation; for the thigh and leg, he directs that the principal flap shall have a length of *one-third* of the limb's circumference, and that the length of the smaller flap shall be *one-half* that of the larger. He also rounds off, somewhat, the angles of the flaps, and makes the posterior flap of skin and fascia only. I have employed this form of amputation, or at least one embracing the same principles, in the upper extremity, and with excellent results; I have preferred, however, to keep the rectangular form of the flaps, as in Teale's method, and to make both flaps include muscle as well as skin and fascia.

Relative Advantages of Different Modes of Amputating.—In the writings of the older surgeons may be found frequent controversial disquisitions on the alleged superiority of one or another mode of amputating over all other plans, and it is within my own recollection that some distinguished operators never resorted to any but the circular incision, while others as invariably employed some variety of the flap method. For my own part, I have long been convinced, both by individual experience and by operations which I have seen done by others, that the particular form of operation chosen, is of comparatively slight importance: provided that sufficient covering be secured for the bone, it matters little whether that covering be in the form of a circular or oval cuff, or of one or two flaps, or whether the corners of the latter be angular or rounded. I shall not dispute, with Liston,[1] the judgment of those "philosophers of the modern Athens," who provoked his wrath and sarcasm by asserting that the wound-area of a circular amputation was less than that exposed by the flap operation; nor shall I deny that the arteries are apt to be cut obliquely in removing a limb by the latter method; but, though I confess to a growing fondness for the old-fashioned circular incision, and find myself employing it more commonly year by year, when the special circumstances of the case do not render it less desirable than some other procedure, yet I cannot conscientiously say that I think that the form of operation adopted exercises any marked influence upon the result. The judgment manifested in determining whether an amputation shall or shall not be performed, and the care taken in the after-treatment of the patient, are of much more importance.

At the same time, the operation which may be best adapted to one particular case, may be less well suited to another; and the surgeon should be sufficiently familiar with all the methods which have been described, to enable him to choose that which is most appropriate in the special circumstances with which he is concerned. If I were to give any general rule, I should say that for the *forearm*, the circular operation was the best, and for the *upper arm*, either that or the modified circular; the latter operation I should prefer for the *upper part of the thigh*, and either it or the simple circular for the *lower part of the leg;* for the *lower* part of the *thigh*, and for the *upper* part of the *leg*, I should recommend the flap method—antero-posterior flaps being chosen in the former, and an external flap in the latter situation. The oval and elliptical operations are particularly well fitted for amputations at the *joints*, while the single-flap and Teale's or Lister's methods will serve a useful purpose where the disease or injury involves less of the tissues on one side of the limb than on the other.

[1] Op. cit., p. 642.

Simultaneous or Synchronous Amputations.

It not unfrequently happens that, as the result of injury or disease, two or even more limbs in the same patient may be so hopelessly disorganized as to call for amputation. Should both or all the operations be done at once? or should the patient be allowed to recover from the effects of one operation before another is attempted? That French surgeon, Faure, against whom Velpeau[1] directed the shafts of his sarcasm, and who proposed that the surgeon should do a single amputation by slow and easy stages, stopping to rest for four or five days after each, and thus prolonging the whole duration of the operation for a fortnight or so, would no doubt have advised without hesitation that but one operation should be done at a time; and in certain cases this advice would be judicious. Thus, in a patient suffering from chronic bone-and-joint disease, scrofulous or syphilitic, it may be good practice to remove the part which causes most suffering, and postpone further operative interference for months, or even years; for even if the other affected parts should not recover themselves (which is always possible), the patient's life would be less endangered by successive operations performed at considerable intervals, than by two or more amputations performed at the same time. Even in cases of gangrene following frost-bite—a not unfrequent cause of double amputation—it may be proper to remove one of the affected members as soon as the line of separation is established, and to postpone the second operation until the patient has recovered from the first.

But in most cases of double or multiple injury, requiring amputation, at least in civil life, the only hope of the patient lies in prompt removal of all the crushed parts. In military surgery, it is somewhat different; gunshot fractures of limbs are often attended with less *immediate* danger than similar compound fractures resulting from other causes, in which the soft parts are more involved; and hence the army surgeon may be justified in amputating only the worst-hurt limb, at first, and in treating the other for a time expectantly, even though he may feel sure that a secondary operation will eventually be required. The prospect of recovery under these circumstances is of course greater than when several limbs have to be removed simultaneously, and hence most of the successful multiple amputations recorded have occurred in military practice.

Quadruple amputations, or amputations of both upper and both lower extremities, have proved successful in the hands of Dr. Alfred Muller, Acting Assistant Surgeon, U. S. A., Dr. Begg, of Dundee, and M. Champenois, a surgeon of the French army. Other cases are referred to by Morand, by Prof. Longmore, and by Southam of Manchester, and two are mentioned by H. Larrey, one patient having been seen at the "Invalides," in Paris, and the other in Algiers. In none of the eight cases do all the operations appear to have been synchronous, though in Champenois's case three limbs were removed on one day, and the fourth two days afterwards. Dr. Koehler, of Schuylkill Haven, Pennsylvania, has recorded a successful *synchronous, triple amputation* (both legs and one arm) in a boy of thirteen, and similar cases are attributed by Prof. Agnew[2] to the late Dr. Stone, of New Orleans, and to an unnamed surgeon of York, Pennsylvania. Another successful triple amputation (not synchronous) has been reported by Léséleuc, of Brest. J. Ritter has reported two cases of triple amputation for gangrene following frost-bite, and other triple amputations have been recorded by Marten, Bruberger, and Field, of Texas.

Double synchronous amputations are not very rare, but (except when the feet or hands only are involved) are, unfortunately, not usually successful;

[1] Op cit., tome ii. p. 356. [2] Principles and Practice of Surgery, vol. ii. p. 374.

Primary
Synchronous Amputation of left leg and right hip joint.
From a patient in the Hospital of the University of Pennsylvania.

eleven such cases, under my own care, have given seven deaths and but four recoveries. In one of these, the right thigh and left leg were simultaneously removed for railway injury by my friend and assistant, Dr. H. R. Wharton; the patient, who was an adult, recovered without a single unfavorable symptom. Another case, which has furnished the subject of the accompanying plate (Plate III.), is worthy of being narrated in more detail:—

George ——, aged fifteen, was admitted to my ward in the University Hospital, while I happened to be in the building, on the afternoon of June 4, 1879, having a short time before fallen from and been run over by a train on the Philadelphia, Wilmington and Baltimore Railroad, which passes not far from the hospital. The right limb had been absolutely torn off above the knee, the femur being badly shattered and the skin and fascia completely separated as far up as the groin. The left leg was also crushed in its lower third, both bones broken obliquely, and the soft parts greatly lacerated. Slow but steady bleeding was going on from the left leg, while on the right side it was only restrained by digital compression of the iliac artery, which had been promptly instituted by Dr. Palmer, the house surgeon, with the aid of two or three senior students who were in the ward when the patient was brought in. Notwithstanding the lad's apparently desperate injuries, I found him in a condition which, while far from promising, did not absolutely forbid an operation, and—surgical instinct forbidding non-interference while hemorrhage was actually present—I determined, with the skilful assistance of Dr. R. A. Cleemann, who was visiting the hospital with me, to amputate. Bleeding being temporarily controlled by a pair of Esmarch's tubes, rolled one around the left leg and the other around the stump of the right thigh, the patient was carefully etherized, and then, having adjusted a Lister's aortic compressor so as to command both iliac arteries, I amputated at the right hip-joint, cutting antero-posterior flaps from without inwards, as in Guthrie's method, making the posterior flap first, and being obliged to include, in the anterior, a good deal of the skin which had been torn up and separated in the original injury. The vessels having been secured, a fold of oiled lint was temporarily placed between the flaps, and then, finding that the patient's pulse permitted it, I turned to the left leg, which I immediately amputated at its middle by the modified circular method. Both the elastic tube and the tourniquet were used on this limb, in the way described on page 570. All bleeding vessels having been tied, both wounds were closed with silver wire sutures, and simply dressed with lint soaked in olive oil (not carbolized), covered with oiled silk, and kept in place with adhesive strips and roller bandages.

During the operations, I had an assistant give repeated hypodermic injections of ether—a syringe-full at a time—and I find by my notes that it was estimated that a fluidounce of ether was consumed in this way. After the patient was put to bed—for I had operated while he lay on the stretcher on which he had been carried to the hospital—the ether injections were continued until he had rallied enough to be able to swallow, and then five grains of carbonate of ammonium were given by the mouth every half hour until thorough reaction had occurred. This was further promoted by the use of external heat, and, though the patient seemed almost moribund when the operations were completed, his condition rapidly improved, and his convalescence from that time proceeded without an unfavorable symptom. An alcoholic dressing was substituted for the oiled lint after the first forty-eight hours; the last ligature came from the leg-stump on the eighth, and the femoral ligature from the hip-wound on the twelfth day. The patient was kept in hospital until January, 1880, his wounds having then been entirely healed for about four months.

As far as my reading goes—and I am confirmed by the opinion of my valued friend the late Dr. G. A. Otis, Surgeon U. S. Army, whose familiarity with the literature of hip-joint amputation was probably greater than that of any man now living—this is the only case recorded in which a successful primary amputation at the hip-joint has been performed synchronously with another major amputation. Among my *unsuccessful* double amputations, I count two cases in which the right arm was removed at the shoulder-joint, in one, in connection with amputation in the lower third of the left leg, and in

the other in connection with amputation of the left upper arm at its middle. Besides cases of double *major* amputation, I have twice had occasion to remove portions of both feet (in one instance the whole foot, on one side) for gangrene resulting from frost-bite; in both of these cases the patients recovered. The particulars of all the cases referred to are compendiously shown in the annexed Table:—

TABLE SHOWING THE PARTICULARS OF ELEVEN CASES OF DOUBLE SYNCHRONOUS AMPUTATION.

No.	Sex and Age.	Nature of Lesion.	Operation.	Result.	Date.	Remarks.
1	Male aged 5 years	Crush of both lower extremities	Amputation of right leg at middle (circular) and left thigh at upper third (modified circular)	Died in 3 hours	1865	Episcopal Hospital.
2	Male aged 35 years	Crush of both lower extremities	Amputation of both legs at knee (flap)	Died in 8 hours	1866	do.
3	Male adult	Crush of both upper extremities	Amputation of right arm at middle (circular) and left arm at upper third (oval)	Died in 3 days	1867	do. Injuries of head also.
4	Female adult	Frost - bite of both feet	Amputation of both feet through metatarsus (antero-posterior flap	Recovered	1871	Episcopal Hospital.
5	Male aged 49 years	Frost - bite of both feet	Amputation of right foot through metatarsus (flap) and left foot at ankle (Syme)	Recovered	1876	do.
6	Male aged 15 years	Avulsion of right and crush of left lower extremity	Amputation at right hip-joint (flap) and of left leg at middle (modified circular)	Recovered	1879	University Hospital.
7	Male adult	Crush of right leg and left foot	Amputation of right leg at middle (modified circular) and left foot at ankle (Syme)	Died in 9 hours	1879	do.
8	Male adult	Crush of both lower extremities	Amputation at right knee (flap) and of left leg at lower third (modified circular)	Died in 4 hours	1880	do. Injuries of head also.
9	Male aged 32 years	Crush of right arm and left foot	Amputation at right shoulder-joint (Larrey) and of left leg at lower third (circular)	Died in 4 days	1880	Episcopal Hospital. Injuries of head also. Slight reactionary hemorrhage.
10	Male aged 25 years	Avulsion of right and crush of left upper extremity	Amputation at right shoulder-joint (Larrey) and of left arm at middle (modified circular)	Died in 11 hours	1880	University Hospital. Injuries of head also.
11	Male adult	Crush of both lower extremities	Amputation at right knee (flap) and of left leg at upper third (flap)	Recovered	1880	University Hospital. Operation by Dr. H. R. Wharton.

It is, I think, better in these synchronous amputations, provided that the circulation is thoroughly controlled with tourniquets, to complete both operations, as far as the knife is required, before pausing to ligate the divided vessels; and, under any circumstances, both limbs should be removed before either stump is dressed. Before the days of anaesthesia, it was sometimes recommended that both operations should be done actually at the same moment, by separate surgeons, it being thought that if the patient's attention

were divided between two focuses of suffering, he would feel less pain from either, than if the operations were performed consecutively; whatever may have been the advantages of such a procedure in former times, there is no occasion for such a course now, and the operations will be certainly more apt to be done well if only one is done at a time.

Dressing the Stump.

We have carried the description of an amputation as far as the closing of the wound with sutures; this is, at the present day, almost universally done before the patient recovers from the influence of the anæsthetic that has been administered, and, provided that ample drainage is secured either by means of the ligature ends or by the use of a tube, the plan is a good one, as avoiding the infliction of pain at the time when the patient is least able to bear it. There was merit, however, in the custom of our ancestors of allowing a wound to "glaze," as they called it—that is, to become smooth and sticky from the presence of lymph—before it was closed; and if there be any reason to fear consecutive hemorrhage, it is a good plan to simply introduce the stitches, without tightening them, and to lay a piece of oiled lint in the wound (as advised by Mr. Butcher, of Dublin), so as to prevent premature adhesion. This may readily be removed, and the wound finally closed, after reaction has occurred, without giving the patient any additional pain. If the stump be a light one (as in the forearm), it is not desirable to employ any means of approximation other than the sutures, though a short strip of plaster may be laid transversely over the ends of the ligatures, to keep them from being caught in the dressings and perhaps pulled upon before they have become loose. If, however, there be heavy flaps, it will be well to give additional support by applying a few narrow adhesive strips *between* the sutures, and in a longitudinal direction. Under no circumstances should a transverse strip be carried *completely around* the stump; any such source of circular compression will probably cause œdema, and may even lead to gangrene, or possibly, as in a case recorded by Sir James Paget,[1] to death. Another mistake, which should be most scrupulously avoided, is the closing of the wound so tightly as to *hermetically seal it;* there is inevitably a considerable flow of sero-sanguineous fluid after an amputation, and if this be confined within the wound, instead of being allowed to escape, painful distension results, and interference with primary union, not to speak of the danger of septicæmia from decomposition.

Various modes of dressing stumps have found favor with modern surgeons; with perhaps one or two exceptions, all are better than the old plan, which still prevailed within my recollection, of applying a large piece of lint smeared with some unctuous substance (often cut in the form of a Maltese cross, and folded closely around the stump), then a thick nest of charpie, and finally a rather tight bandage. I shall describe briefly several of the stump dressings which have obtained most favor in recent years, concluding with that which, in common with many other surgeons, I am myself in the habit of employing, and which I would venture to designate as the "simple dressing for amputations."

Cold-water Dressing.—Introduced into British surgery by Liston, this is still a favorite mode of dressing amputation wounds in military practice, and

[1] Clinical Lectures and Essays, p. 63. Second Edition. London, 1879.

Fig. 153.

Irrigating apparatus for cold-water dressing.

was very extensively employed during our late war. The stump is simply laid upon a pillow protected with a piece of oil-cloth and a towel or fold of linen, and then another piece of linen, or lint, wrung out of cold water, laid over it, and constantly moistened by an attendant, or, if practicable, by the adjustment of an irrigating apparatus (Fig. 153). There is no better or more soothing application to a recent stump, in hot weather, than this simple cold-water dressing; it, however, requires constant supervision on the part of the attendant, and, unless care be taken to arrange the pillow and oil-cloth so that the drip may fall into a bucket or basin suitably placed, the water will flow backwards into the bed and keep the patient constantly wet, thus exposing him to great discomfort, as well as to the risk of becoming chilled, and, perhaps, falling a victim to pneumonia or other internal inflammation. Hence while recognizing the advantages of this mode of dressing in army practice, or in cases of emergency, I do not recommend its general employment.

In connection with the cold-water dressing of amputation wounds, I may briefly mention the *continuous bath* of Langenbeck and Lefort, recently revived by Prof. Hamilton, of New York, and, with the modification of carbolizing the bath, so as to make it antiseptic, by Prof. Verneuil, of Paris.

Air Dressing.—I would venture to propose this name for the plan of treating amputation wounds recommended by Mr. Teale, of Leeds, and Prof. Humphry, of Cambridge, and advocated with the great ability and eloquence which characterized all his writings, by the late Sir J. Y. Simpson, of Edinburgh. Mr. Teale, after directing that the wound should be closed with sutures, says:—[1]

"After the patient has been carried to bed, the stump is laid on a pillow, over which a large sheet of gutta-percha tissue has been spread. *No dressing whatever* is required in the early part of the treatment. A light piece of linen or gauze is thrown loosely over the stump and pillow, and these are protected from the pressure of the bedclothes by a wire-work guard. . . . The attendants and nurses must be strictly enjoined not to lift the stump from the pillow without the authority of the surgeon. As there are no dressings to be soiled, and therefore to require removal, the stump generally need not be raised from the pillow for many days, or even for two or three weeks. When there is a discharge of matter, the nurse must remove it frequently by a soft sponge from the subjacent gutta-percha without lifting the stump."

Prof. Humphry,[2] refering to the well-known fact that wounds of the face not unfrequently heal by the first intention, says:—

"This is due, in great measure, to the vital qualities of these parts, and, in some degree, also, I apprehend, to the fact that they are usually exposed to the air, their edges being held in contact merely by sutures. For some years we have adopted this plan after amputations, and all, or nearly all, other operations. The integuments are united by sutures placed at intervals of about an inch; and the wound, as well as the adjacent surface, is left quite exposed to the air; no plaster, bandage, or dressing of any kind being placed upon it."

[1] Op. cit., page 9.
[2] British Medical Journal, October, 1860, p. 840, quoted by Simpson, Acupressure, page 130. Edinburgh, 1864.

And Sir J. Y. Simpson, discoursing on "The General Inutility of Dressings," says :[1]—

"I believe . . . that after the sides and edges of a wound are properly approximated and adjusted with its metallic stitches, the best dressing, as a general rule, is—nothing, absolutely nothing. . . . I have found that occasional streams of cold air directed upon the wound or its vicinity from a pair of bellows prove both most beneficial locally in keeping down morbid heat and irritation, and are most grateful to the feelings of the patient."

Pneumatic Occlusion and Pneumatic Aspiration.—In contrast to the views of the writers just quoted, who attributed a positively curative action to the contact of atmospheric air, we may next consider the modes of dressing recommended by several French surgeons who, by preventing exposure of amputation wounds to air, endeavor to place them in a condition analogous to that of subcutaneous injuries. As pointed out by H. Larrey in the discussion before the French Imperial Academy of Medicine, the germ of these ideas may be found fairly set forth in the Treatise on Wounds of Cæsar Magatus,[2] a Franciscan Monk and Professor at Ferrara, who lived from 1579 to 1647; but the first practical application of the method in modern times, may probably be attributed to Chassaignac,[3] who, in connection with his system of drainage tubes, recommended that the wound should be closely covered with strips of plaster, and so excluded from the air.

Pneumatic Occlusion.—The name of "Pneumatic Occlusion" was given by M. Jules Guérin to a method of dressing wounds of all kinds, including those made by amputation, which he described before the *Académie de Médecine*, in February, 1865.[4] The apparatus required for this mode of treatment consists of (1) an exhausted metallic receiver, provided with gauge and stopcock; (2) a series of envelopes or sleeves of vulcanized India-rubber, of various forms and dimensions, ending in vulcanized India-rubber tubes, which are firm enough to resist atmospheric pressure; and (3) a series of very fine elastic envelopes which are capable of adapting themselves to the inequalities of the part to which they are applied, and which are permeable to the atmosphere, and are placed inside of the others. The stump is first surrounded with the thin elastic envelope, and then placed inside of the India-rubber sleeve, the neck of which is made to clasp the limb with sufficient closeness to prevent its slipping; the exhausted receiver is then attached, and, the stopcock being turned, the air and gases contained in the sleeve pass into the receiver, and the former, with the fine enveloping tissue, yielding to atmospheric pressure, mould themselves to the surface of the stump, which they hermetically seal.

A somewhat similar apparatus, but employed with a different purpose—that of keeping the stump at an even temperature—had been previously suggested by Jules Guyot, whose mode of treatment was designated as the *Incubation Method.*

Pneumatic Aspiration is the name given by M. Maisonneuve[5] to a method of dressing stumps, not unlike that of M. Guérin, which has just been described. It consists—

[1] Acupressure, etc., page 116. Edinburgh, 1864.
[2] Cæsaris Magati Scandianensis De Rara Medicatione Vulnerum, etc. Venetiis, 1676.
[3] Sédillot, op. cit., tome i. p. 342.
[4] Bulletin de l'Académie Impériale de Médecine, tome xxxi. p. 396.
[5] Practitioner, vol. i. p. 1. London, 1868.

". . . in submitting the stump of the amputated limb to continued suction (vacuum), so as to draw off all the liquids as fast as they are formed, and to convey them away before they have had time to putrefy. This is how the process is carried out; after having stopped the hemorrhage in the usual way, by means of ligatures to the vessels, I clean the wound with the greatest care, wash it with alcohol, and wipe it with a dry cloth. I bring the edges together with a few strips of diachylon, but without opposing an obstacle to the flow of the secreted liquids. I then apply a layer of lint soaked in antiseptic liquids, such as tincture of arnica, solution of carbolic acid, or other suitable substance, and finally I fold the whole in a few bands of linen soaked in the same preparations. It is only after this preliminary dressing that the apparatus for exhausting the air is applied. The apparatus consists (1) of an extremity of India-rubber, shaped like a lady's muff, and intended to embrace the stump, and a tube of the same substance; (2) of a vessel of four or five litres ($3\frac{1}{2}$ quarts to one gallon) capacity, provided with a mouth-piece pierced with two holes; and (3) of an exhausting pump, fitted with a flexible tube. The stump covered with its bandage is first placed in the 'India-rubber muff,' whose orifice embraces exactly the integuments of the limb, and the tube is placed in connection with one of the holes in the mouth-piece of the vessel. To the other aperture I adapt the tube from the exhausting pump, and then I work the piston. In a short time the air of the vessel is in great part drawn off, and the remainder is rarefied. The liquids of the dressing, mixed with those which proceed from the wound, follow the air, and flow into the vessel. The 'India-rubber muff,' deprived of the air it had contained, applies itself closely to the limb. The pressure of the atmosphere exercises—through the intervention of the India-rubber—a considerable compression of the stump, and thus keeps the divided surfaces in contact, and, combined with the continued exhaustion produced by the rarefaction of the air in the vessel, prevents all accumulation of liquid, and thus promotes and favors rapid cicatrization."

Could any systems of dressing be more unlike than those which we have just considered, and the "air-dressings" of Teale, Humphry, and Simpson; and yet the advocate of each mode deplores the great mortality of amputations in the hands of other surgeons, and confidently puts forward his own method as that which by clinical experience he has proved to be the best.

It has for many years been the boast of modern surgery that it had abandoned the old doctrines of "digestion" and "mundification" of amputation-wounds, and that it now endeavored to promote the quick healing of stumps by primary union. And yet in two of the most highly lauded methods of dressing employed at the present day, no attempt is made to close the wound for days after the operation; I allude to the *perchloride of iron dressing* of M. Bourgade, of Clermont-Ferrand, and to the *open method* of dressing stumps employed by Prof. J. R. Wood, of New York.

Perchloride of Iron Dressing.—The practice of cauterizing an amputation-wound is an old one,[1] but the principle upon which M. Bourgade founds his method, first brought before the International Medical Congress of Paris, in 1868, differs from that upon which the older surgeons acted. Recalling the well-known facts that *recent wounds* are more prone to absorb septic materials, whether from their own secretions or from the atmosphere, than *granulating surfaces*, and that septic poisoning is less common after operations performed with the *caustic* than after those accomplished by the use of the *knife*, M. Bourgade[2] endeavors to render the latter as inoffensive as the former, by applying to the whole cut surface a strong solution of *perchloride of iron* (Pravaz's solution, sp. gr. 30° Baumé). Hemorrhage having been arrested, and the wound carefully washed, the whole surface is covered with charpie saturated with the solution in question, care being taken that the action of the drug is exerted equally on all parts, bones and vessels, as

[1] See the quotation from Vigo, *supra*, page 554.
[2] Fort, Cours de médecine opératoire, p. 150. Paris, 1880.

well as muscles and connective tissue. Wet charpie is then placed outside to diminish the irritation of the skin, and this constitutes the whole dressing. The perchloride of iron "combines with" the tissues with which it is in contact, and at the end of twelve hours forms a thick, solid magma, a "tough cuirass," which completely isolates the subjacent tissues from the influence of surrounding agents. Suppuration begins from the sixth to the tenth day —sometimes later—and the charpie, becoming detached, leaves a sloughy-looking surface which soon becomes covered with healthy granulations. The wound is then dressed with aromatic wine, and the flaps may be brought together so as to induce union by "secondary adhesion."

Open Method.—This mode of dressing stumps, which, except as to the use of sutures, somewhat resembles that which I have called the "air-dressing" of Teale and Humphry, is principally advocated by Prof. James R. Wood, of New York.[1]

"After a limb has been amputated, the flaps are not even approximated, but left entirely open. A pillow of oakum is placed under the stump, which is allowed to rest upon this support until the wound is nearly healed. A small piece of gauze is placed over the contour of the stump, and a cradle is placed over the limb, so that the clothes may not come in contact with the painful extremity. This is all the dressing that is employed: no sutures are used except in the lateral skin-flap method, as will be described." [One or two stitches are placed at the anterior angle of the wound, so that the flaps may cover the bone, but the rest is allowed to gape.] "No adhesive plaster is employed, no oil-silk is placed over the stump, no bandage is applied, no dry charpie is stuffed into the wound, no fenestrated compresses are placed between the flaps; in other words, the stump is left entirely alone, just as the surgeon made it in his amputation. The wound is thus allowed to drain freely, and the stump is gently washed at frequent intervals by means of an Esmarch's wound-douche. The water in this irrigator is impregnated with crystals of carbolic acid, and, after this ablution, balsam of Peru (which makes a fine stimulating application) is poured over the granulating surface. The discharge which falls from the wound is removed every few hours in order to secure perfect cleanliness. . . . . The stump is then washed at frequent intervals until suppuration has nearly subsided in the wound, and then the flaps are gradually approximated by means of strips of adhesive plaster."

The historian of Prof. Wood's cases, Dr. F. S. Dennis, professes his faith in Pasteur's and Lister's doctrines as to the evil effects produced by microscopic organisms floating in the air, but believes that their bad influence may be sufficiently neutralized by frequently washing the stump with carbolized water in the manner described. We have next to consider two modes of dressing which aim at the entire exclusion of these organisms; the *antiseptic dressing* of Prof. Lister, and the *wadding-dressing* of M. Alphonse Guérin.

Antiseptic Dressing.—In a certain sense, almost all of the modern modes of dressing wounds may be termed "antiseptic," and indeed it is not unusual for the advocates of "Listerism" to claim all the *good results* obtained by surgeons who do not follow their mode of practice, as due to an unconscious or involuntary antisepticism, while the *bad results* are attributed to careless or wilful neglect of antiseptic precautions. But by the name *antiseptic dressing*, in this article, I mean the peculiar mode of dressing stumps advocated by Prof. Lister, formerly of Glasgow and Edinburgh, but now of King's College, London, and founded in a firm belief in the baleful influence of bacteria and other micro-organisms, and in the absolute necessity of excluding them from the wound. The antiseptic agent commonly employed is carbolic acid, but

[1] Dennis, Treatment of Amputations by the Open Method. New York Medical Journal, vol. xxiii. p. 8, 1876.

Prof. Lister has quite recently announced that an equally good effect may be obtained from the oil of eucalyptus. The second volume of this work will contain an Article specially devoted to the Antiseptic System, and I shall therefore merely say in this place that, the operation having been performed under a spray of carbolized steam (one to forty), and the instruments, sponges, etc., having been throughout kept thoroughly antiseptic—the limb itself should have been first washed with a 1–20 solution of carbolic acid—the vessels are tied with carbolized catgut, and the wound (amply furnished with drainage tubes) closed with "antiseptic sutures;" the "protective" dipped in a 1–40 solution is next adjusted, and covered with one or more layers of "antiseptic gauze," dipped in the same solution; then with numerous layers of dry gauze; next with one of mackintosh; and lastly with a final layer of gauze, and a bandage of the same material. The outer dressings are not renewed until the discharge has begun to soak through them, while the inner dressings are sometimes allowed to remain for weeks together.

Wadding Dressing.—As in Prof. Lister's dressing the bacteria and micrococci are met and destroyed, in their effort to reach the wound, by successive layers of gauze impregnated with carbolic acid, so by M. Guérin's device they are mechanically arrested by a huge thickness of cotton-wadding, and, unable to get either in or out, miserably perish in its meshes. All hemorrhage from the stump having been checked, M. Guérin washes the wound, and indeed the whole limb, with carbolized water, has it gently dried, and held immovably in one position by assistants, while the dressing is applied. Sutures may or may not be used. Drainage tubes are not required. A thick pad of cotton is first placed over either flap, and then two strips of wadding, three inches wide and ten or twelve long, are applied with their middle to the end of the stump, and their extremities folded down upon the limb above and below; these strips are crossed by two others of similar dimensions, and a fifth, applied circularly, holds them all in position. A long band of wadding is then employed like a bandage, to completely cover in the stump and the limb to a point half way between the two nearest joints; the amount of cotton used is to be enough to make the diameter of the covered limb at least three times that which it naturally possesses. Ordinary bandages are next applied over the wadding, the first turns being quite loose, and the bandages then gradually made more and more tight, until the final turns exercise a very energetic but equable compression over the whole stump. Usually thirteen bandages of eleven yards each are required for this purpose. When the dressing is complete, the limb can be moved in any direction, or the stump struck, without giving the patient any pain. If in the course of a few hours, any blood is found leaking through the bandages, a thick square of wadding and an additional bandage are applied. The dressing must be examined every day during the first week, and, if necessary, still more bandage added so as to keep up firm compression. The dressing is allowed to remain, as a rule, for from twenty to twenty-five days; it should be applied, and, when necessary, reapplied, in a special room and not in the ordinary ward.[1]

For want of space I can merely mention the "*Bordeaux Method*," which may be considered as in some degree a combination of Lister's and Guérin's plans, embracing the use of drainage tubes, very accurate adjustment of the flaps with sutures and collodion, washing the stump with carbolized water. and covering it with cotton;[2] and the *Earth Dressing* of Dr. Addinell Hewson,[3]

[1] Fort, op. cit., pp. 159 et seq. [2] Ibid., p. 177.
[3] Earth as a topical application in Surgery. Philadelphia, 1872.

which, as its name implies, consists in the use of prepared earth or dried clay, placed in immediate contact with the wound.

What is the legitimate inference to be derived from a consideration of the various and very dissimilar methods of dressing stumps which have now been referred to—methods, it must be remembered, which have been, each without exception, lauded by their promoters as superior to all others, and, in the opinion of their advocates, proved to be so by the unerring test of clinical experience? Is it not that the particular mode in which a stump is dressed is, after all, of comparatively little importance, and that we must look for information as to the probable result of an amputation, rather to the nature of the lesions which render the operation necessary, and the constitutional condition of the patient, than to the influence of any extraneous circumstances? This question will be referred to again when we come to consider the statistics of amputation, and is merely suggested here in connection with the mode of treatment next to be described, and which I have ventured to call the *simple dressing* for amputation wounds.

Simple Dressing.—In the first place, let us consider what are the requisites for a good stump dressing. There must obviously be ample means provided for *drainage;* or pain, if not worse, will be caused by the accumulation and retention of the sero-sanguineous flow which inevitably follows an amputation. Hence, as already mentioned, care must be taken not to apply the stitches too close together, and, if sufficient drainage be not afforded by the ligatures, one or two fenestrated India-rubber tubes may be laid in the wound and brought out at the angles. Then, whatever dressing is employed *should not be liable to stick to the wound*, lest it interfere with the exit of discharges and cause pain when it is renewed; hence wet dressings are preferable to salves or ointments, and upon the whole I know of nothing which answers a better purpose than *pure laudanum*, the use of which in dressing stumps I learned many years ago from that excellent surgeon Dr. Joseph Pancoast. The laudanum is no doubt antiseptic, from the alcohol which it contains, and its use is certainly very soothing to the patient; it prevents, to a great extent, if not entirely, that painful jerking of the stump which is so apt to follow amputation. Mr. Bryant accomplishes the same purpose by bandaging the stump firmly to a padded splint, but with the laudanum dressing this is unnecessary, and the stump will be found to rest very comfortably upon a soft pillow, which should be covered with a piece of India-rubber cloth and a clean towel. At the second dressing, forty-eight hours after the operation, I commonly substitute diluted alcohol for the laudanum, and continue this dressing until the wound is nearly healed, after which the ointment of the oxide of zinc may be employed instead. While my preference is for pure laudanum, as a first dressing, I have occasionally used, with excellent results, diluted laudanum, or lead-water and laudanum, or simply olive oil. I have no particular objection to carbolized oil, if it be not so strongly impregnated with the acid as to produce irritation of the skin, but have seen no advantage from its employment.

Whatever material be employed for the dressing, this must be *kept moist;* otherwise it will adhere to the edges of the wound and produce irritation. This object is best accomplished by saturating with whatever preparation is employed, a large piece of lint, laying it *underneath* the stump, folding it over the end, and then again (doubled) from either side, so that on top of the stump are placed five layers of wet lint, constituting a reservoir from which the medicated fluid is gradually drawn downwards. The whole should be covered moreover with oiled silk, or some other impermeable tissue which will keep

the part moist for at least forty-eight hours. After the second dressing, I renew the applications every day, and the waxed paper (which is much cheaper than oiled silk) may conveniently be substituted. As long as wet dressings are employed, no pads of charpie or oakum are necessary, but the dressing, with its impermeable envelope, may be simply held in position by the turns of a light, loosely applied, recurrent bandage. In the later stages of the case, when the wound is dressed with zinc ointment, a little oakum may be loosely applied externally, as a means of mechanical protection.

After-treatment of the Stump.—When the dressings are to be *removed*, the bandage should be cut, and the oiled silk and lint laid off from the stump before this is raised from the pillow; the surgeon at the same time examines the sutures, untwisting or cutting any that are too tight, and, if a plug of wax has been applied to the medullary cavity of the bone, gently withdraws it by pulling on the wire to which it is attached. An assistant then slips his hand under the stump, carrying it well down towards the end, and then firmly but gently lifts the part, and supports it while the soiled dressings are removed, the stump washed and dried, and the new dressings adjusted. This is not a painful process; patients often dread the manipulation beforehand, but it is very seldom that they complain at the time, and they almost invariably experience a decided increase of comfort when the dressing is completed.

The *washing* of the stump is to be very gently effected with a clean soft sponge, or bunch of tow or oakum—the late Mr. Callender employed a camel's hair brush—and tepid water, colored with a little Condy's fluid (solution of permanganate of potassium), which is an excellent deodorizer and disinfectant. As far as possible, the water should be allowed to flow over the stump without touching this with the sponge itself. The part is then gently sopped until it is dry, with a clean, soft towel, and the new dressings adjusted. When the wound has fairly well healed, and the stump is no longer sensitive, the washing may be more thorough—a little oil of turpentine being employed to remove the adhesive plaster which sticks to the skin, and the whole well douched afterwards with soapsuds and water.

If silk *sutures* have been used, they may be properly taken away on the third or fourth day; metallic sutures may be allowed to remain much longer, indeed often until the wound is firmly healed. The *ligatures* should be allowed to *drop of themselves*, but the surgeon may gently *feel* them, to ascertain if they are loose, after a week in the case of the smaller, and after ten days in that of the larger vessels. *Under no circumstances should a ligature be rudely pulled away.* Apart from the risk of hemorrhage, I have more than once known the somewhat forcible withdrawal of a ligature, attended by slight bleeding, showing that the granulating surface had been broken, to be followed in a few hours by a chill and the development of fatal pyæmia. If short cut animal ligatures have been employed, they are commonly dissolved in the fluids of the stump, and are not seen after the operation. If *acupressure* has been used, the pins or needles may be taken from the smaller vessels on the second, and, from the larger, on the third, fourth, or fifth day, according to circumstances. If *drainage tubes* have been employed, they may be withdrawn about the end of the first week.

I have called this the *simple dressing* for stumps, but, it may be asked, is not the *air-dressing* simpler still? No doubt it is—inasmuch as nothing is less than something—but I do not think it as satisfactory. Prof. Humphry's remark as to the rapid healing of face wounds is certainly true; but it is also true that face wounds heal quite as rapidly, and with much less discomfort to

the patient, if covered with a strip of lint kept wet with glycerine and water, than if left dry. Moreover, I had the opportunity, some years ago, of seeing a number of amputations treated after Teale's method by a very careful surgeon, and I can honestly say that I have never seen so large a proportion of inflamed and sloughing stumps before or since. I have no doubt that Prof. Wood's "open method" is better than Teale's or Humphry's, as avoiding any risk of undue tension by sutures; but the abandonment of all effort to obtain primary union seems to me to be a step in the wrong direction, and one not compensated for by any other feature of the plan in question. Besides, I believe that positive benefit is derived from the constant contact of an anodyne fomentation.

Structure and Diseases of Stumps.

Structure of Stumps.—When first formed, a stump contains all the tissues utilized in the amputation (unless these have sloughed before the occurrence of cicatrization), but soon afterwards various changes are observed, which continue progressively for a long time afterwards. Thus the *muscular* substance gradually disappears, and, no matter how full and plump the stump may have seemed at first, it in time assumes a withered look, and the skin forms, as it were, a loose bag around the end of the bone. The fibrous and tendinous portions of the muscles remain, however, and undergo conversion into a dense fibro-cellular mass which protects the bone, and renders it less liable to cause ulceration of the overlying skin or cicatricial tissue when subjected to pressure. The *bone* itself undergoes changes, becoming rounded off, and a button of new osseous tissue closing the medullary cavity, which is to a great extent obliterated. The *vessels*, at first filled with clots reaching to the nearest anastomosing branches, become in time changed into firm fibrous cords, continuous with the vessels above. The *nerves* are thickened, and become bulbous at their extremities, constituting a form of neuroma; these bulbous enlargements consist mainly of fibro-cellular tissue, but are abundantly supplied with nerve fibrils.

In connection with these alterations of structure, met with in the stump itself, very curious changes have been noted in distant organs. Thus Dr. Dickinson, Dr. Lockhart Clarke, and M. Vulpian, have observed localized atrophy of the *spinal cord* which corresponds to the side on which the amputation has been practised, and similar changes have likewise been noticed by Drs. Webber, Genzmer, Dickson, Leyden, and Dreschfield. Bèrard, many years ago, observed atrophy of the anterior roots of the *spinal nerves* corresponding to the amputated part, and Chuquet and Luys have observed atrophy of the *brain* on the side *opposite* to that of the amputation.

A patient who has submitted to one of the large amputations is apt to become *fat:* this is apparently due to the fact that, while the supply of nutriment continues the same as before the operation, the demand for it is diminished by a part of the body having been removed, and accumulation of fat is the consequence; this is still further aided, in the case of amputations of the lower extremity, by the resulting inability to take the proper amount of exercise. Among patients of the lower class, the enforced idleness which often follows as a necessary sequel of amputation, is unfortunately apt, in many cases, to lead to the formation of intemperate habits.

Diseases of Stumps.—Any of the tissues which enter into the structure of a stump may be morbidly affected and give rise to pain or other annoyance.

Sloughing of the skin and connective tissue which cover the stump, is occasionally met with, and may be due to bruising of the parts by the injury which rendered the amputation necessary; to undue tension, from original insufficiency of covering, or from subsequent swelling conjoined with too tight closure of the wound by sutures, etc.; or to constitutional causes, as in cases of senile gangrene, or of that frightful affection which has already been alluded to, the true "traumatic or spreading gangrene." Sloughing is more apt to occur after flap amputations than after those done by the circular method; but I have once seen the entire cuff of a circular operation slough off as cleanly as if it had been cut by a knife. The *treatment* of a sloughing stump consists in removing all sources of tension, by cutting stitches, etc., and applying a fermenting or charcoal poultice till the dead parts are removed, when an attempt may be made to diminish the size of the remaining wound by the judicious use of strapping.

Erysipelas or *Diffuse Cellulitis* may attack a stump, and either forms a serious complication. The *treatment* consists in removing all the sutures, applying a soothing dressing (such as diluted alcohol, or olive oil), wrapping the limb in cotton, and administering full doses of the tincture of the chloride of iron, which may be conveniently combined with the solution of acetate of ammonium, as in the following formula:—℞. Tincturæ ferri chloridi f℈j–f℈ij, syrupi f℥ss, liquoris ammonii acetatis f℥vss. M. Sig. "A tablespoonful every two hours."

Hospital Gangrene is a very serious affection when following a recent amputation, but is fortunately not very common at the present day. The *treatment* consists in thoroughly cauterizing the whole surface of the wound with bromine or a strong solution of permanganate of potassium (℈j to f℥j), and bringing the patient under the constitutional effect of opium. When the disease is arrested, the wound will often heal with great rapidity, but occasionally the destruction of tissue may have been so great as to necessitate a second operation.

Spasm of the muscles of a stump is a painful complication, which is chiefly met with a few hours after the recovery from anæsthesia, and which, by causing the limb to be jerked off the pillow on which it rests, tends to interfere with primary union. The *treatment* ordinarily recommended, is the application of a tolerably firm bandage, with or without a splint, and the internal administration of anodynes. As already mentioned, this complication is very seldom met with when the laudanum dressing is employed. Cases of persistent and intractable *choreic spasm* of a stump, occurring some time after amputation, have been recorded by Dr. S. Weir Mitchell and Dr. H. C. Wood.

Retraction of the muscles sometimes occurs and continues progressively for many days or even weeks after an amputation, and occasionally constitutes a really serious complication by interfering with the healing of the stump, causing troublesome ulceration of the cicatrix (if healing has already occurred), and giving the part a peculiar, pointed appearance which has suggested the name of *conical* or *sugar-loaf stump*, a condition which may also depend upon sloughing, or upon hypertrophy of the bone. The ulcer on the end of the stump, caused by muscular contraction, is called the *mechanical ulcer*, and is often very intractable. The *treatment* consists in the application of a firm circular bandage, from above downwards, so as to relieve tension by restraining the action of the muscles, and, as it were, coaxing the soft

parts downwards, until the ulcer has had time to heal. Another plan is to employ extension by means of a weight, applied either with the ordinary adhesive plaster stirrup, as in fractured thigh, or, as advised by Mr. Bryant, through the medium of an arched splint attached to the front and back of the limb. The last resort, in a case of conical stump which is constantly re-ulcerating, or which is too tender to permit the use of an artificial limb, is resection of two or more inches of the end of the bone; an operation which happily is attended with very little risk, and of which the result is usually quite satisfactory.

Contraction of the tendons in the neighborhood of the stump may cause trouble, by giving rise to deformity and dragging upon the cicatrix; this is particularly observed in connection with the *medio-tarsal*, or Chopart's, amputation of the foot, after which operation, the natural arch of the foot being destroyed, the tendo Achillis may be drawn upwards by the gastrocnemius and soleus muscles, and a painful form of talipes equinus result, the cicatrix being forced against the sole of the shoe in walking. This occurrence can usually be prevented by taking care to make the flaps of ample size, and by the judicious use of bandages, splints, and weight extension, if any tendency to retraction be noticed. Tenotomy may be resorted to if other means prove insufficient.

Hemorrhage from a stump may occur at any time before the wound is completely healed, though it is not usually looked for after the safe separation of all the ligatures. I have, however, known fatal hemorrhage from the femoral artery, in a syphilitic subject, to occur four weeks after amputation of the thigh, and when all the ligatures had come away and the patient had been going about for some time. Sometimes the bleeding comes from small vessels which were not noticed at the time of the operation, but which begin to spout when reaction occurs (*consecutive* or *reactionary hemorrhage*). *Secondary hemorrhage* from a stump may be due to the bleeding vessel having been imperfectly secured in the first instance—as by tying it too near the cut end, so that the noose can slip off before repair is complete, or by including too much tissue with the artery, so that in a day or two the knot becomes loose—or to a diseased condition of the arterial coats themselves, rendering them liable to ulceration, or, more rarely, to the formation above the ligature of an aneurismal swelling which subsequently undergoes rupture. Capillary oozing or *parenchymatous hemorrhage* sometimes occurs after amputation, and appears to be due to thrombosis of the venous trunks interfering with the return circulation. The *treatment* of hemorrhage from a stump, if the bleeding be but slight in amount, consists in elevating the part and applying cold (by means of an ice-bag), and moderate pressure, and in administering ergot, digitalis, and opium; but if these means fail, or if it appear that a large vessel is bleeding, more decided measures must be adopted. If the process of healing be not far advanced, the stump should be reopened, the surgeon breaking up the recent adhesions with his fingers, and the bleeding artery should then be tied in the wound, it being sometimes necessary for this purpose to dissect the vessel up for a short distance, and thus free it from the surrounding tissues. If, however, the hemorrhage has not occurred until the greater part of the stump is firmly healed, it will probably be better to secure the artery immediately *above* the wound rather than in the wound itself; this may be done by cutting down and applying a ligature, but may be much more readily accomplished by acupressing the vessel according to Simpson's first method—passing a long pin deeply across the known course of the vessel, so as to go below it, and, if necessary, increasing the pressure by applying a pad of lint or cork, and a figure-of-eight ligature, externally.

This is one of the few cases in which acupressure seems to me to possess greater advantages than the ligature, and I would urgently recommend it as the best means of controlling hemorrhage under these circumstances; the pin can be introduced without the necessity of etherizing the patient, and the operation, when the patient is already very much weakened by bleeding, is altogether a much less formidable one than cutting down and searching for the artery. Ligation of the main artery at a distance from the wound, though recommended by Liston, is now generally regarded—and I think justly—as a bad operation, particularly in the lower extremity; it adds a serious complication in itself, exposes to considerable risk of gangrene, and is moreover often ineffectual in permanently arresting the hemorrhage; in the upper extremity, it may be sometimes resorted to with advantage, but when the lower limbs are concerned a better plan is to acupress the vessel in the way already described, and, if necessary, re-amputate when the patient has rallied enough to bear a second operation.

Aneurismal enlargement of the arteries of a stump has already been alluded to as being an occasional cause of hemorrhage. Mr. Erichsen, in his "Science and Art of Surgery," describes and figures a remarkable case of *aneurismal varix* occurring after amputation at the ankle.

Neuromata, or painful nerve-tumors, are often met with in stumps. The bulbous enlargements of the cut ends of the nerves occur, indeed, as already pointed out, in all stumps, but the term *neuroma* is not ordinarily employed, unless these enlargements are painful. The pain, which in these cases is sometimes very distressing, is due, according to Weir Mitchell, to the existence of a true neuritis, or of a state of sclerosis which results from inflammatory changes. The *treatment* is unfortunately not very satisfactory; if the pain were evidently connected with any distinct tumor, resection of the growth, and of two or three inches of the nerve with which it was connected, would be indicated; under other circumstances, it would be proper to cut down and forcibly stretch the nerve which supplied the painful region, or, if this failed, to excise a couple of inches from the continuity of the nerve and turn its distal end downwards, so as to prevent reunion; or, if the whole face of the stump seemed to be neuralgic, a re-amputation might be properly resorted to. These various operations, however, though perfectly justifiable under the circumstances supposed, by no means insure complete relief from suffering. The late Dr. Nott placed on record a remarkable case in which the patient submitted to no less than three re-amputations of a neuralgic stump, and three nerve-excisions, and yet was not cured at the end of this persevering treatment. As *palliative measures*, where an operation is not considered necessary, the application of leeches, ice, and counter-irritants, may be of service, as may the topical use of the strong tincture of aconite root, or hypodermic injections of morphia. Relief was obtained, in a case recorded by Girard, by the repeated employment of electro-puncture.

Periostitis, *osteitis*, or *osteomyelitis*, or all of these affections simultaneously, may attack the bone of a stump, and in some cases may lead to very serious consequences. *Subperiosteal suppuration*, unless the pus be promptly evacuated by a free incision, is apt to lead to extensive necrosis,[1] and sometimes, by implicating the epiphyseal junction,[2] or even secondarily the neighboring joint,

[1] Subperiosteal suppuration sometimes receives the name of *acute necrosis*, but the necrosis is a consequence of the disease rather than the disease itself.

[2] The sequence of events is usually the other way, *epiphysitis* preceding subperiosteal suppuration. (See Macnamara, Lectures on Diseases of Bones and Joints, pp. 69, 75. Second edition. London, 1881.)

may place the patient's life in jeopardy, and require re-amputation. *Diffuse suppurative osteomyelitis* is always a very grave affection, often ending in pyæmia and death, and particularly when it occurs in the femur, a bone specially exposed to this destructive form of inflammation when its medullary cavity is laid open, as it necessarily must be in most amputations of the thigh. König reports a cure, in a case of this kind, effected by scooping out the diseased medulla and stuffing the cavity with cotton saturated with a strong solution of chloride of zinc; but, ordinarily, the best mode of *treatment* consists in re-amputating at the nearest joint—an operation which, though apparently of a desperate character, has proved very successful in the hands of Roux and Arlaud, and has been advantageously resorted to by Sir J. Fayrer, even after the development of pyæmic symptoms.

Necrosis is a very common affection of stumps. In most cases the death of bone is limited to a more or less perfect ring, corresponding to the line of section, and is apparently due to the bruising of the part by the teeth of the saw; when, however, the necrosis follows upon osteitis, subperiosteal suppuration, or osteomyelitis—or all combined—it is sometimes very extensive, and may involve almost all that remains of the shaft of the bone. Every pathological or surgical museum embraces specimens of the long, conical, and often tubular sequestra which are found under these circumstances, and which are simply the result of inflammatory action of a high grade. An ingenious attempt has been made to explain the occurrence of these sequestra by attributing it to injury of the nutritious artery, which is, of course, often divided in amputations; but it seems to have been overlooked that a precisely similar form of necrosis occurs as a result of osteitis in cases in which no operation at all has been performed. Not only is the sequestrum often tubular, but it is not unfrequently lined, as well as surrounded, with living bone—the medulla undergoing a retrograde metamorphosis into osseous tissue at the same time that an involucrum is being formed by the periosteum. This fact was long ago observed by Copland Hutchison,[1] and more recent illustrations have been recorded by several writers, including M. Demarquay, of Paris, Prof. Markoe, of New York, and Dr. Packard, of this city; the first philosophical explanation of the occurrence appears to have been given by M. Ollier, of Lyons. The *treatment* of necrosis in a stump consists in removing the sequestrum as soon as it has become loose; this can usually be effected without difficulty by simply seizing the sequestrum with forceps, and drawing it out with a rocking or twisting motion; occasionally, however, the dead bone may be firmly held in place by the periosteal formation of new bone around it, or even by osseous bands extending from this to the ossified medulla—under which circumstances the involucrum must be cut away until the source of obstruction is removed. Under no circumstances can simple necrosis in a stump, no matter how extensive, necessitate re-amputation. This operation may, however, as already mentioned, be required by what is sometimes called *acute necrosis*, but which should more properly be termed diffuse subperiosteal suppuration.

Caries is sometimes met with in the bone of a stump, usually when the amputation has been performed for scrofulous or syphilitic disease, or, if for injury, when the patient is a subject of one of these diatheses. The *treatment*, besides the adoption of suitable constitutional measures, consists in injecting the sinuses which lead to carious bone, with tincture of iodine, one of the mineral acids properly diluted, or, which I have sometimes used with advan-

[1] Some Practical Observations in Surgery, illustrated by cases, page 130. London, 1816.

tage, the preparation introduced by M. Notta under the name of the "Liqueur de Villate," which may be made according to the following formula: R. Zinci sulphatis, cupri sulphatis, āā gr. xv; liquoris plumbi subacetatis, f℥ss; acidi acetici diluti vel aceti albi, f℥iijss.—M. As a last resort, the stump may be laid open and the carious bone removed with osteotrite and gouge, or, possibly, a re-amputation may be found necessary.

Hypertrophy of the bone after an amputation, has already been alluded to as one of the causes of a conical or sugar-loaf stump. This is observed in patients who have not attained their full growth, and principally in amputations of the *leg* and *upper arm;* its occurrence in these rather than in other situations, is accounted for by the well-known physiological fact that, owing to the direction taken by the nutritious arteries in the several bones, and the consequent period at which the epiphyses become united to the diaphyses, the chief growth of the *lower extremity* is from the epiphyses in proximity to the knee, while that of the *upper extremity* is from those of the wrist and shoulder. Hence amputations of the *thigh* and *forearm* remove the principal sources of growth for the portions of bone which remain, while amputations of the *upper arm* and *leg* leave these sources of growth, and in a few years the bones of stumps in these situations may be too long for the soft parts which were originally ample for their covering. If any *treatment* is required in a case of this kind, resection of the overgrown bone is the only remedy likely to be of service.

Adventitious bursæ are sometimes formed over the bones of stumps from pressure of the pad or artificial limb used in walking. If such a bursa should become painful, the mechanical arrangement of the prothetic apparatus employed should be altered, so as to relieve the part from pressure; and if this be not sufficient, an attempt may be made to cause obliteration of the bursa by injecting tincture of iodine, or establishing a seton; or excision of the bursa itself may be resorted to.

Prothetic Apparatus and the Adaptation of Artificial Limbs.

One of the earliest records which we have of a successful effort to supply the place of an entire limb lost by amputation, is given in the history of François de la Noue, a celebrated Huguenot officer, born A. D. 1531, who lost his left arm at the siege of Fontenay. Having at first refused amputation—his arm was shattered by the shot of an arquebuse—preferring to die rather than to be incapacitated for fighting, he was at length persuaded by his friends to submit himself to the surgeon's hands, and the Queen of Navarre herself held his arm during the operation. An *iron arm* supplied the place of the missing member, and gave its bearer the sobriquet of "Bras de Fer;" the artificial limb served to hold his horse's bridle, and enabled the gallant captain to engage in fresh battles with renewed ardor.[1] Ambroise Paré describes and figures several varieties of artificial arms and legs—the former made of iron, boiled leather, or glued paper, and the latter of wood. These he obtained, he says, from a locksmith of Paris, named "le petit Lorrain," and their mechanism was so perfect as to enable the wearer to imitate the natural movements of the parts which had been lost, and even to hold a pen for writing.[2] Among the artificial legs is one for "poor men," which is

[1] See Malgaigne's edition of Paré, already quoted, tome ii. p. 617, note.
[2] Op. cit., tome ii. p. 615.

in all essential particulars the same as the "box-leg," which we still often see at the present day. The chief objection to the iron arm made by "le petit Lorrain" was its weight, which was so great that it could only be worn for short periods; and it is told to the praise of the Nuremberg mechanic who about the same time, or possibly earlier, made the iron hand worn by Goethe's hero, Götz von Berlichingen, that the artificial member supplied for that gallant soldier's use weighed but *three pounds*.

Very ingenious substitutes for lost limbs are available at the present day, and the mechanic's art is enabled to supply any deficiency, from the loss of a single finger to that caused by an amputation at even the hip or shoulder-joint.

PROTHETIC APPARATUS FOR THE UPPER EXTREMITY.—The simplest form of artificial arm for an *amputation above the elbow*, consists of a neatly-fitting sheath of leather terminating in a block to which can be attached a hook, a knife, a fork, or, for show purposes, a wooden hand; by curving the arm, as suggested by Mr. Bigg, at a point corresponding to the missing elbow, the appearance of the artificial limb is very much improved, while a joint, allowing of motion at the elbow by means of a concealed wheel and ratchet, moved by the other hand, makes the limb still more useful. In cases of amputation at the *shoulder-joint*, apposition is effected by means of a leather cap covering the shoulder and side of the chest. For stumps *below the elbow*, a similar apparatus is applicable, of course without the joint. Such a contrivance as that above described is usually all that patients ask for, and I have known great use made of even a simple sheath and fixed hook: indeed, the large majority of men who lose an arm, do not employ any artificial substitute, finding that, with a little practice, one arm can reasonably do the work of two.

For special cases, however, something more is required. The natural motions of the wrist can be imitated; a spring placed within the artificial thumb allows a pen to be held between that and the forefinger, and thus enables the patient to write; and finally an ingenious arrangement of levers, springs, or pulleys, concealed in the hand, permits the fingers to be moved as in the natural member. With M. Bechard's artificial arm, two hands are furnished—one naked and one gloved—to replace each other according to the needs of the occasion. Among the most ingenious forms of artificial arm

Fig. 154.

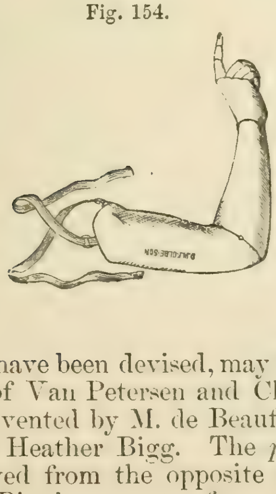
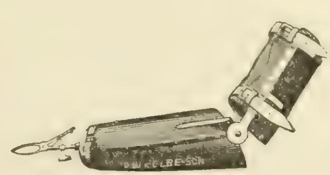


Fig. 155.



Artificial arm.

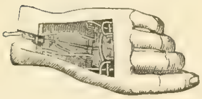
which have been devised, may be specially mentioned, besides that of Bechard, those of Van Petersen and Charrière, and, among less expensive appliances, that invented by M. de Beaufort, which has been further usefully modified by Mr. Heather Bigg. The *power*, in cases of amputation above the elbow, is derived from the opposite arm, through the medium of cords of catgut, but in Bigg's apparatus for amputation below the elbow, is derived from the

mutilated arm itself. The accompanying illustrations (Figs. 154–157) show the mechanism of the artificial arm and hand manufactured by Mr. Kolbé, of

Fig. 156.

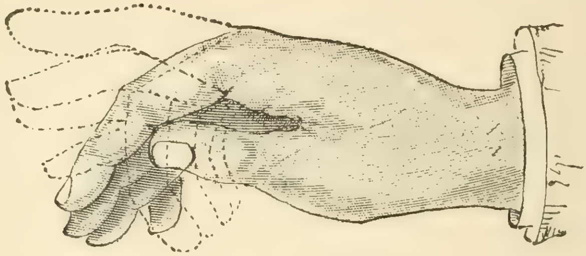
Artificial hand.

Fig. 157.



Mechanism of artificial hand exposed.

Fig. 158.

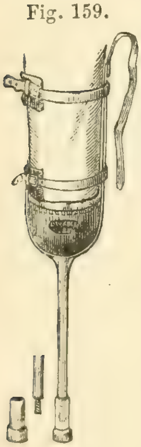


India-rubber hand.

this city (Philadelphia), which are among the best in the American market. Fig. 158 shows an ingenious artificial hand, made of India-rubber by Mr. Marks, of New York.

Prothetic Apparatus for the Lower Extremity.—Artificial legs are of much more value in a practical point of view than artificial arms, which are indeed not seldom voluntarily laid aside by those who possess them, or are only worn upon special occasions. The simplest form of artificial leg is the "box-leg" (Fig. 159), adapted for the reception of the bent knee after amputation at what was formerly called the "point of election," a short distance below the tubercle of the tibia. This apparatus is, as already remarked, almost identical with the "poor-man's leg," described by Ambroise Paré more than three centuries ago. An improvement over this is the "bucket" or "socket-leg," which is adapted to the extended limb, and is so arranged as to prevent pressure upon the cicatrix at the end of the stump. For amputation *below the knee*, a socket closely fitting the limb is employed, with a leather thigh-band or lateral straps, or, which is much better, a limb with *two* buckets, one for the leg and the other surrounding the thigh, thus completely taking off the weight from the end of the stump, and, at the same time, greatly facilitating the act of throwing the leg forward in walking. For amputations *above the knee*, the bucket should be so arranged as to transfer all pressure to the tuberosity of the ischium. Care must also be taken so to adjust the artificial limb that the centre of gravity of the body shall fall within its base, as in the normal condition. Ingenious artificial appliances for amputations of the *foot or ankle* (Chopart, Syme, Pirogoff, etc.) are supplied by Bigg, of London, Marks, of New York, and Kolbé, of Philadelphia, while Charrière, of Paris, has devised a limb for use after amputation at the *hip-joint*, in which motion is permitted at points corresponding to all three articulations of the lower extremity.

Fig. 159.

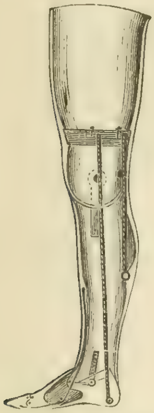


Box-leg.

Among the more elaborate forms of artificial leg which have acquired popularity in modern times, may be mentioned the "Anglesey leg" (so called from having been adopted by the Marquis of Anglesey, who lost his leg at Waterloo), and the "Palmer leg," manufactured by B. F. Palmer, of Philadelphia, which, from its lightness, and the facility of walking which it affords, has always been a favorite in this country. Fig. 160 shows the mechanism of a leg made by Mr. Blanck, of Philadelphia, which closely resem-

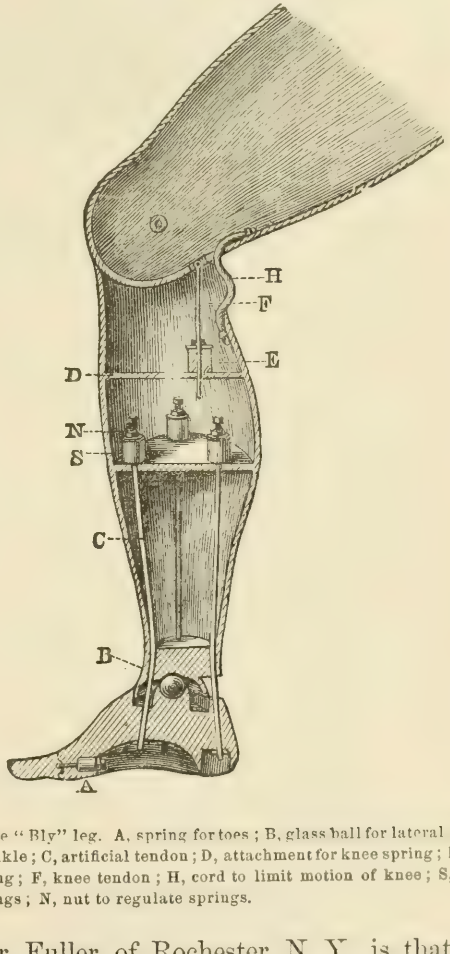
bles the "Palmer leg," and is really a very useful and satisfactory piece of mechanism. Various ingenious devices have been adapted in order to provide *lateral and rotatory*, as well as *antero-posterior motion* at the ankle-joint, those specially worthy of mention being found in the forms of apparatus made respectively by Dr. Bly, of Rochester, Mr. Marks, of New York, and Mr. Kolbé, of Philadelphia. The peculiarity of the "Bly leg" (Figs. 161, 162),

Fig. 160.



The "Blanck" leg.

Fig. 161.



The "Bly" leg. A, spring for toes; B, glass ball for lateral motion at ankle; C, artificial tendon; D, attachment for knee spring; E, knee spring; F, knee tendon; H, cord to limit motion of knee; S, ankle springs; N, nut to regulate springs.

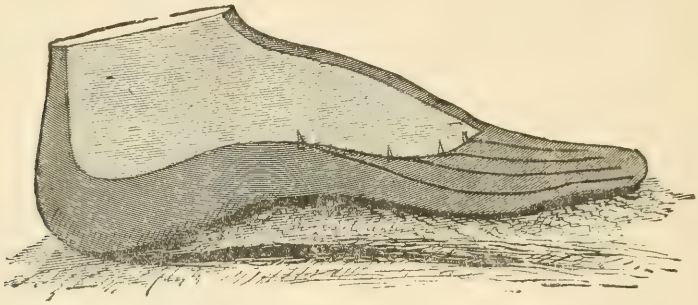
Fig. 162.

Mechanism of ankle in the "Bly" leg. B, glass ball; C, tendons: G, leg piece.

which is now manufactured by Mr. Fuller, of Rochester, N. Y., is that the ankle-joint is formed by a ball of polished glass playing in a vulcanite socket, motion being afforded by means of India-rubber "compression" springs, with cords which represent the natural tendons. The "Marks leg" (Fig. 163) dispenses with a joint altogether, the necessary motion in different directions being provided for by the flexibility and elasticity of the foot itself, which is made of India-rubber surrounding a smaller wooden frame. The "Kolbé leg" (Figs. 164, 165) affords lateral motion at the ankle by giving the steel ankle bolt a globular enlargement at its centre, corresponding to hemispherical depressions in both foot and leg pieces, the ends of the bolt passing loosely through holes in the metal side straps, and being furnished with India-rubber supports so as to permit the necessary movements.

The use of metallic springs, in artificial limbs for the lower extremity, is now very generally abandoned in favor of those made from India-rubber.

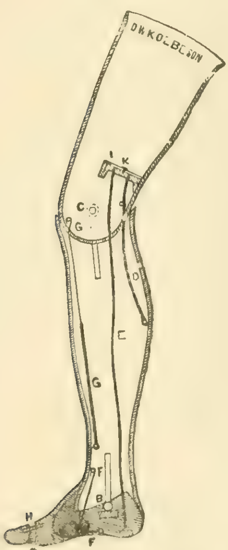
Fig. 163.



India-rubber foot of the "Marks" leg.

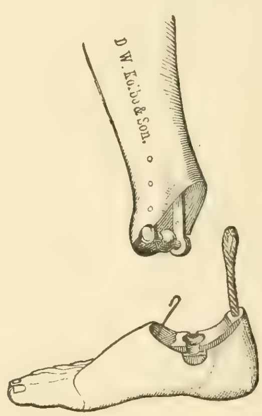
Mr. Heather Bigg, of London, has modified the mechanism of the "Bly leg," by employing but a single tendon, which passes through the axis of the

Fig. 164.



The "Kolbe" leg. A H, joint of toes; B, ankle; C, knee; F F, artificial tibialis anticus; G G, artificial quadriceps femoris; E I and D K, artificial gastrocnemius and soleus.

Fig. 165.



Mechanism of ankle in the "Kolbe" leg.

joint, while retaining the ball and socket character of the articulation. No artificial leg should be applied until the stump is thoroughly healed and solid, three months being the *minimum* interval which should be allowed to elapse after the amputation.

Mortality and Causes of Death after Amputations.

The rate of mortality after amputation has always been a favorite subject of study with workers in surgical statistics, and, as already pointed out, al-

most every inventor of a new method of operating, or new mode of dressing, from the days of Benjamin Bell[1] to our own, has adduced figures to prove that his plan is better than that of his predecessors. But the circumstances of cases are so different, that the statistics thus furnished have, so far, been of very little value. If it could be shown that by any special form of operation—as, for instance, Teale's—or under any special mode of dressing—as, for instance, Lister's or Guérin's—a large number, say a hundred, consecutive cases of (1) primary amputation, (2) in the lower third of the thigh, (3) for compound fracture by railway injury, (4) in healthy young men between 20 and 25 years of age, (5) operated on in any particular hospital, and (6) with a certain, definite degree of care exercised in the constitutional and hygienic after-treatment, furnished decidedly better results than the same number of consecutive cases of precisely the same character, and under precisely the same circumstances, except as regards the form of operation or mode of dressing; such a demonstration would afford a powerful argument in favor of the particular plan recommended. But such a demonstration has not been as yet furnished, nor, indeed, as far as I know, even attempted, by the advocates of any of the methods which have been referred to; and a moment's reflection will show how useless it must be to compare tables of cases which are really not comparable, either in regard to the age and general condition of the patients, the nature of the lesions requiring operation, the hygienic surroundings, the care given to after-treatment, or other particulars. Nor can the practice of one surgeon, taken as a whole, be fairly compared with that of another; for they may operate under very different circumstances: one in a richly endowed and well-ordered hospital, the other in a parsimoniously conducted almshouse; one chiefly upon children, the other almost exclusively upon adults; one principally in cases of chronic joint-disease, the other in cases of very severe and complicated injuries. Again, one surgeon advises and practises the operation of joint-excision, and only amputates in the worst cases, while his colleague amputates in all cases, and of course has better statistics.

While, however, I would deprecate any attempt to decide the question of the best mode of operating, or of dressing stumps, by any figures now available for the purpose, I am far from undervaluing the importance of statistical investigation, in which indeed I have myself done a good deal of work. Certain points in reference to the results of amputations can only be (and, I think I may say, have been) established by statistical inquiry, such as the comparative risks of primary and secondary operation, of operations for injury as compared with those for disease, etc. But before giving the figures which I have collected in reference to these questions, I beg to submit the accompanying Table, containing the record of the first one hundred consecutive, single, major amputations which I have performed, *ipsis manibus*, during the last nineteen years, taken from my note books. My experience in double amputations has already been given (page 592). I have, besides, done seventeen partial amputations of the hand or foot, all of which have ended in recovery; this is exclusive of finger and toe amputations, of which I have kept no record.

[1] Benjamin Bell, after deploring the large mortality which had before his time attended amputation, declared: "In the present improved state of the operation," that is, with the *triple incision*, of which he considered himself the inventor, "I do not imagine that one death will happen in twenty cases; even including the general run of hospital practice: and in private practice, where due attention can be more certainly bestowed upon the various circumstances of the operation, the proportion of deaths will be much less." (System of Surgery, Seventh edition, vol. vii. p. 254. Edinburgh, 1801.) It is hardly necessary to add that these glowing anticipations have not as yet been realized.

TABLE SHOWING THE RESULTS OF ONE HUNDRED CONSECUTIVE CASES OF SINGLE MAJOR AMPUTATION.

No.	Date.	Sex, Age, and Occupation.	Nature of Case.	Nature of Operation.	Result.	Hospital.	Remarks.
			I. Amputations at the Wrist.				
1	Oct. 12, 1863	M. 17.	Gunshot fracture right metacarpus from bursting of gun	Antero-posterior flaps from without inwards	Recovered	Episcopal	Primary.
			II. Amputations through the Forearm.				
2	Sept. 25, 1862	M. .... Soldier	Gunshot fracture left forearm	Teale's rectangular flaps	Recovered	Chester	Secondary.
3	Oct. 28, 1862	M. 22. Soldier	Gunshot fracture left radius; necrosis	Antero-posterior flaps from without inwards	Died	"	Secondary. Death from secondary hemorrhage and gangrene after tying brachial artery.
4	Oct. 22, 1863	M. 52. Rope-maker	Crush of left forearm by machinery	do.	"	Episcopal	Primary. Death from exhaustion.
5	March 23, 1865	M. 50. Merchant	Crush of right forearm by railway injury	do.	"	"	Primary. Death from delirium tremens.
6	March 29, 1865	F. 72.	Caries of right wrist-joint	Circular method	Recovered	"	For disease.
7	Sept. 2, 1865	M. 19. Operative	Crush of right forearm by machinery	do.	"	"	Primary.
8	March 14, 1867	M. 30. Laborer	Crush of right forearm received in blasting	Teale's rectangular flaps	"	"	"
9	March 20, 1868	M. 8.	Crush of right hand by railway injury	do. (modified)	"	"	"
10	Dec. 31, 1869	M. 42. Laborer	Avulsion of right forearm by "hay cutter"	do.	Died	"	Primary. Death from pyæmia.
11	March 7, 1870	M. 23. Brakeman	Crush of left forearm by railway injury	Circular method	Recovered	"	Primary.
12	Feb. 26, 1872	M. 25. Cabinet-maker	Left hand nearly severed by circular saw	do.	"	"	"
13	Oct. 2, 1877	M. 23. Brakeman	Crush of left forearm by railway injury	do.	"	University	"
14	April 13, 1878	M. 67. Farmer	Osteo-sarcoma of right radius and ulna	do.	"	"	For disease.
15	May 28, 1878	M. 3.	Crush of left forearm by railway injury	do.	"	Episcopal	Primary.
16	Sept. 14, 1878	M. 21.	Crush of right hand and wrist by railway injury	do.	"	University	"
17	May 22, 1879	F. 12. Operative	Gangrene of left hand after injury by machinery	Teale's rectangular flaps (modified)	"	Episcopal	Secondary.
18	Jan. 6, 1880	M. 29. Brakeman	Crush of left hand and wrist by railway injury	Circular method	"	University	Primary.
19	Oct. 10, 1880	M. 27.	Crush of right wrist by fall from tree; arteries ruptured; comatose	do.	Died	"	Primary. Death in 2 hours from cerebral injury.

TABLE SHOWING THE RESULTS OF ONE HUNDRED CONSECUTIVE CASES OF SINGLE MAJOR AMPUTATION.—*Continued.*

No.	Date.	Sex, Age, and Occupation.	Nature of Case.	Nature of Operation.	Result.	Hospital.	Remarks.
			III. *Amputations at the Elbow.*				
20	April 20, 1880	M. 14. Rope-maker	Crush of right forearm by machinery	Circular method	Recovered	Episcopal	Primary.
			IV. *Amputations through the Upper Arm.*				
21	Oct. 19, 1862	M. .... Soldier	Gunshot fracture of right humerus	Modified circular method	Recovered	Chester	Secondary.
22	March 26, 1864	M. 42.	Simple fracture of right humerus and crush of hand by railway injury. Injury of head. Erysipelas and spreading gangrene	do.	Died	Episcopal	Intermediate. Death in 20 hours; laceration of brain found at autopsy.
23	June 1, 1864	M. 32. Soldier	Gunshot wound of left forearm: necrosis	Long skin flaps	Recovered	Cuyler.	Secondary.
24	June 21, 1864	M. 17. Operative	Avulsion of right arm by machinery	Modified circular method	"	Episcopal	Primary.
25	Aug. 26, 1864	F. 13. Operative	Avulsion of right arm by machinery	Teale's rectangular flaps	"	"	"
26	Aug. 27, 1864	M. 17. Laborer	Crush of right arm by wagon wheel	Modified circular method	"	"	"
27	April 24, 1865	M. 48. Butcher	Gunshot fracture of left ulna	do.	Died	"	Secondary. Death from delirium tremens.
28	April 27, 1865	F. 3.	Crush of right forearm by railway injury	do.	Recovered	"	Primary.
29	March 15, 1866	M. 50. Operative	Crush of right hand by machinery; necrosis of ulna and secondary hemorrhage	Skin flap operation	Died	"	Secondary. Death from secondary hemorrhage. Acupressure used.
30	Feb. 4, 1867	M. 28. Operative	Crush of left forearm by machinery	Circular method	Recovered	"	Primary.
31	Jan. 13, 1869	M. 24. Brakeman	Crush of right arm by railway injury	Modified circular method	Died	"	Primary. Death from pyæmia.
32	Jan. 19, 1871	M. 15. Operative	Laceration of right forearm by machinery, followed by tetanus	Circular method	"	"	Secondary. Death from tetanus.
33	Jan. 20, 1871	M. 30. Farmer	Crush of right arm by loaded wagon	Modified circular method	"	"	Primary. Death from pyæmia.
34	Oct. 30, 1871	M. 13. Operative	Avulsion of right arm by machinery	do.	Recovered	Children's	Primary.
35	March 14, 1872	M. 35. Operative	Crush of left arm by machinery	do.	"	Episcopal	"
36	June 5, 1875	M. 14. Operative	Crush of right arm by machinery	Circular method	"	"	"
37	June 11, 1877	M. 33. Blacksmith	Crush of left arm by machinery	do.	"	"	"
38	Sept. 19, 1877	M. 23. Brakeman	Gangrene after laceration of left arm by railway injury	Teale's rectangular flaps	"	University	Secondary.
39	Jan. 1, 1879	M. 35. Brakeman	Crush of right arm by railway injury	Circular method	"	"	Primary.
40	April 15, 1881	M. 20. Brakeman	Crush of right forearm by railway injury	Double skin flaps	"	"	"
41	May 6, 1881	M. 23. Laborer	Avulsion of left arm by railway injury	Circular method	"	"	"

TABLE SHOWING THE RESULTS OF ONE HUNDRED CONSECUTIVE CASES OF SINGLE MAJOR AMPUTATION.—*Continued.*

No.	Date.	Sex, Age, and Occupation		Nature of Case.	Nature of Operation.	Result.	Hospital.	Remarks.
				V. *Amputations at the Shoulder.*				
42	Sept. 2, 1864	M. 26.	Laborer	Gangrene from tight bandaging after simple fracture of right forearm	Larrey's method	Died	Episcopal	Intermediate. Death in 2 hours from shock.
43	March 29, 1867	M. 14.	Schoolboy	Necrosis of right humerus	do.	Recovered	"	For disease.
44	Feb. 25, 1868	M. 12.	......	Subperiosteal suppuration, acute necrosis, and epiphysitis of right humerus	do.	"	"	"
45	Jan. 31, 1869	M. 46.	Mechanic	Crush of right arm; left hemiplegia	do.	Died	"	Primary. Death in 3 days from cerebral complications.
46	March 27, 1873	M. 31.	Laborer	Crush of left arm by railway injury	Dupuytren's method	Recovered	"	Primary.
				VI. *Amputations at the Ankle.*				
47	June 5, 1875	M. 14.	Schoolboy	Crush of right foot by railway injury	Syme's method	Recovered	Episcopal	Primary.
48	March 7, 1876	M. 6.	......	Crush of right foot by railway injury	do.	"	"	"
				VII. *Amputations through the Leg.*				
49	Oct. 24, 1863	M. 30.	Laborer	Compound fracture of left leg by railway injury	Antero-posterior skin flaps	Recovered	Episcopal	Secondary.
50	Feb. 20, 1865	M. 35.	Spinner	Crush of right leg by railway injury	do.	"	"	Primary.
51	March 6, 1867	M. 21.	Laborer	Caries of right leg and ankle	Antero-posterior flaps	"	"	For disease.
52	Jan. 20, 1870	M. 23.	Copper-smith	Crush of left leg by railway injury	do.	Died	"	Primary. Death from pyæmia.
53	April 1, 1872	M. 35.	......	Crush of left ankle by railway injury	Circular method	"	"	Primary. Death in 5 days from exhaustion.
54	Jan. 11, 1873	M. 18.	Brakeman	Crush of right ankle by railway injury	Sédillot's external flap	Recovered	"	Primary.
55	Feb. 11, 1873	M. 49.	Engineer	Gangrene following injury of left leg by machinery	Oval skin flap (antero-internal)	"	"	Secondary.
56	March 9, 1873	M. 14.	Operative	Crush of left foot by railway injury	Oval method	"	"	Primary.
57	Jan. 16, 1874	M. 33.	......	Caries of left tarsus and gangrene following perforating ulcer	Circular method	"	"	For disease.
58	Sept. 1, 1875	M. 59.	Laborer	Compound fracture of left leg by railway injury; secondary hemorrhage	Modified circular method	"	"	Secondary.
59	July 23, 1877	M. 49.	......	Warty ulcer of right leg with caries of tibia	Sédillot's external flap	"	University	For disease.
60	Dec. 20, 1877	M. 43.	......	Crush of left ankle by railway injury	Circular method	"	"	Primary.

TABLE SHOWING THE RESULTS OF ONE HUNDRED CONSECUTIVE CASES OF SINGLE MAJOR AMPUTATION.—*Continued.*

No.	Date.	Sex, Age, and Occupation.	Nature of Case.	Nature of Operation.	Result.	Hospital	Remarks
			VII. *Amputations through the Leg.*—Continued.				
61	Jan. 25, 1878	M. 19.	Crush of left leg by railway injury	Sédillot's external flap	Recovered	University	Primary.
62	April 5, 1878	M. 32.	Crush of right leg by railway injury; fracture of ribs and injury of head	Modified circular method	Died	"	Primary. Death next day from visceral injury.
63	April 25, 1878	M. 40.	Caries and ulceration of left foot	External flap	Recovered	Episcopal	For disease.
64	May 6, 1878	F. 35.	Caries of right foot and ulceration of leg. Pregnant	Sédillot's external flap	"	"	For disease. Aborted 2 weeks after stump healed, and fatal pelvic abscess [followed.
65	June 19, 1878	M. 38.	Crush of left ankle by railway injury	Modified circular method	"	University	Primary.
66	Jan. 20, 1880	M. 18.	Crush of right ankle by railway injury	Sédillot's external flap	"	"	"
67	April 27, 1880	M. 20.	Crush of right foot by railway injury	Circular method	"	"	"
68	May 1, 1880	M. 38.	Painful stump and osteitis of right leg	do.	"	"	For disease. Reamputa-[tion.
69	Nov. 4, 1880	M. 11.	Crush of right foot by railway injury	Sédillot's external flap	"	"	Primary.
70	Jan. 27, 1881	M. 23.	Gangrene of right foot following injury from cart	Teale's rectangular flaps	"	"	Secondary.
71	Feb. 5, 1881	M. 18.	Caries of right foot	Sédillot's external flap	"	"	For disease.
72	May 20, 1881	M. 16.	Crush of left ankle by railway injury	Circular method	"	"	Primary.
73	July 22, 1881	M. 25.	Crush of right foot by railway injury	do.	"	"	"
			VIII. *Amputations at the Knee.*				
74	July 19, 1877	M. 53. Machinist	Avulsion of left leg by railway injury; patient insane	Elliptical method	Died	University	Primary. Death from acute mania.
75	March 30, 1878	M. 56. Teamster	Warty ulcer of cicatrix following compound fracture of left leg 39 years before	Antero-posterior skin flaps	Recovered	"	For disease.
76	Nov. 30, 1878	F. 45 (or older)	Sloughing ulcer and elephantiasis of right leg	do.	Died	"	For disease. Death in 5 days from exhaustion.
77	Dec. 24, 1879	M. 35.	Crush of left leg by railway injury	do.	Recovered	"	Primary.
			IX. *Amputations through the Thigh.*				
78	Nov. 6, 1862	M. .... Soldier	Suppurative osteo-myelitis following gunshot contusion of left thigh	Circular method	Died	Chester	Secondary. Death in 7 hrs. from shock and exhaus-[tion.
79	Feb. 29, 1864	M. 13. Schoolboy	Necrosis of left tibia and disease of knee following measles	Antero-posterior flaps	Recovered	Episcopal	For disease.
80	Feb. 17, 1865	M. 13. Schoolboy	Necrosis of left tibia and disease of knee following a fall	do.	"	"	"

TABLE SHOWING THE RESULTS OF ONE HUNDRED CONSECUTIVE CASES OF SINGLE MAJOR AMPUTATION.—*Concluded.*

No.	Date.	Sex, Age, and Occupation.	Nature of Case.	Nature of Operation.	Result.	Hospital.	Remarks.
			IX. *Amputations through the Thigh.*—Continued.				
81	April 25, 1865	M. 14. Operative	Crush of left thigh by machinery	Modified circular	Died	Episcopal	Primary. Death in 18 hrs.
82	Jan. 25, 1868	M. 11. Schoolboy	Crush of right leg by railway injury	Antero-posterior flaps	Recovered	"	Primary. [from shock.
83	Sept. 20, 1870	M. 5.	Disease of right knee; enlargement of liver	do.	"	Children's	For disease.
84	March 4, 1873	M. 51. Laborer	Acute suppurative arthritis of left knee from injury	do.	Died	Episcopal	For disease. Death in 8 days from exhaustion.
85	Jan. 2, 1874	M. 13.	Caries of left tibia and disease of knee	do.	Recovered	Children's	For disease.
86	March 16, 1874	M. 18.	Necrosis of left tibia and disease of knee	do.	"	Episcopal	"
87	May 19, 1876	M. 28.	Recurrent caries after excision of left	do.	"	"	"
88	Jan. 12, 1878	F. 45.	Enchondroma of left femur [knee	do.	"	University	"
89	April 6, 1878	M. 12.	Necrosis of left tibia and disease of knee and ankle	do.	"	"	"
90	June 16, 1878	M. 25.	Compound luxation of right knee; artery injured	do.	Died	Episcopal	Primary. Death from tetanus.
91	Sept. 3, 1878	M. 3.	Disease of right knee-joint	do.	Recovered	Children's	For disease.
92	Oct. 23, 1878	F. 10.	Disease of left knee joint	do.	"	"	"
93	Oct. 27, 1880	M. 36.	Crush of left leg by railway injury	do.	Died	University	Primary. Death in 6 days from vomiting and exhaustion.
94	Jan. 1, 1881	M. 61.	Diffuse right popliteal aneurism threatening rupture	do.	"	"	For disease. Death in 4 days from exhaustion and continuous vomiting.
95	May 24, 1881	M. 8.	Necrosis of left tibia and disease of knee	do.	Recovered	Children's	For disease.
96	May 29, 1881	M. Adult	Crush of left thigh by railway injury	do.	Died	University	Primary. Death in 8 hours from shock.
97	June 30, 1881	M. 37.	Suppurative arthritis of left knee-joint from syphilis	do.	"	"	For disease. Death on 28th day from secondary hemorrhage.
			X. *Amputations at the Hip.*				
98	Jan. 14, 1868	F. 22.	Gunshot fracture of right hip-joint	Guthrie's method	Died	Episcopal	Secondary. Death in 3 hours from shock.
99	Feb. 8, 1877	M. 20.	Crush of right thigh by railway injury	do.	"	"	Primary. Death in 7 hours from shock.
100	Feb. 28, 1877	M. 22.	Osteo-sarcoma of right femur	do.	Recovered	"	For disease.

The mortality after amputation has been steadily diminishing since the early days of our art, as a result no doubt of the use of anæsthesia, the ligature, simple dressings, and other improvements in operative surgery in general. From a death-rate of two in three, which was considered a favorable exhibit by the pioneers in this operation,[1] the mortality, even in city hospitals receiving a fair share of accident-cases, has fallen to one in three or four;[2] and when we consider that a large proportion of our operations are now done for injuries of the gravest character, such as were simply not known in the days of our ancestors, it will be seen that the improvement has been still more marked. And while it, of course, cannot be denied that the death-rate of the operation is still a very high one, it will be found, by an analysis of the causes of death after amputation, that most cases which terminate fatally, do so in consequence of circumstances totally unconnected, if not with the operation, at least with the particular form of the operation, and with the special mode in which the after-treatment is conducted.

Thus, taking my own Table of one hundred cases, the deaths are twenty-eight; rather less than the average of hospital practice, but still a large number. But upon looking further, we find that six patients died shortly after the operation,[3] as a *direct result of their injuries*, and that these six cases included one amputation at the hip, one at the shoulder, and two high up in the thigh. Four cases died in from two to twenty hours, from the *shock of the operation*, these four including one hip and one shoulder-joint amputation, and one high up in the thigh; two of the four were moreover *intermediate* operations, which are well known to be especially apt to prove fatal. Three deaths occurred from *secondary hemorrhage;* one of these was after amputation of the forearm by the double flap method, the bleeding coming from the interosseal artery; the brachial was ligated, but gangrene followed, and hemorrhage recurred and ended fatally eight days afterwards. In a second case, one of amputation of the arm, death occurred on the third day from hemorrhage from the brachial artery which had been secured by acupressure, a mode of treatment which, under the fascination of Sir James Y. Simpson's eloquent writings, I was then using. The third case was one of thigh amputation for acute destructive inflammation of the knee, resulting from syphilis in its worst form, such as we seldom witness at the present day; the ligatures had come away safely, and rather early, and the patient had been out of bed for about a week, when bleeding from the femoral artery occurred on the 28th day, and death followed in a few hours. Two deaths were from *tetanus* (existing, in one case, before the operation), two from *delirium tremens*, and one from *acute mania*. Eighteen of the twenty-eight deaths in my Table are thus accounted for, and of the remaining ten, six are put down as from exhaustion, and four as from pyæmia. Of the six patients who died from *exhaustion*, three were over 50 years of age, and all over 35; five cases proved fatal in from four to six days (three thigh and two leg amputations), and one, a forearm-amputation which had been complicated by secondary hemorrhage, on the 23d day; this death might have been attributed to pyæmia, or other form of septic poisoning, but that a careful autopsy failed to reveal any lesion significant of such a condition, while it did reveal advanced visceral disease of the heart, liver, and kidneys. All of the six patients were persons in feeble health, and five of them obviously unfavorable subjects for any operation. The first of the four deaths from *pyæmia* occurred on February 2, 1869, and the last on February 2, 1871, the two others having occurred on February 3, and February 7, 1870. Thus, for more than ten years, I have not lost a case of amputation from pyæmia. These four deaths all took place in the same ward of the Epis-

[1] Benjamin Bell says: "Before the invention of the tourniquet, this operation [amputation] was attended with so much hazard, that few surgeons ventured to perform it: nay, long after the introduction of this instrument, the danger attending it was so great, that more than one-half perished of all who had resolution to submit to it." (Op. cit., vol. vii. p. 254.)

[2] I am, of course, aware that statistics giving a much smaller death-rate have been published by various hospitals; but on examining these cases in detail it will generally be found that they embrace a *small* proportion of amputations for *injury*, and a *large* proportion of amputations for *disease*.

[3] One in 2 hours, one in 7 hours, one in 8 hours, one in 18 hours, one on 2d day, one on 3d day.

copal Hospital, and from these limitations of time and space, and from the fact that I dressed stumps then precisely as I did before and have done since, I am disposed to attribute them to local and climatic rather than to any other causes.

TABLE SHOWING CAUSES OF DEATH IN TWENTY-EIGHT FATAL CASES OF MAJOR AMPUTATION.

Direct result of injury	6	Acute mania	1
hock	4	Exhaustion	6
Secondary hemorrhage	3	Pyæmia	4
Tetanus	2		—
Delirium tremens	2	Total	28[1]

Deducting six deaths from the direct result of injury, and three from delirium tremens and acute mania—which have certainly no connection with the operation *per se*—the mortality would be reduced to a little over 20 per cent., or one in five. My first 50 cases gave 18 deaths (including all that have occurred from pyæmia), or, making the corresponding deductions, 14 out of 46, a mortality of 30 per cent.; while my second 50 cases gave but 10 deaths, or, with the corresponding deductions, 5 out of 45, a mortality of only 11 per cent.

The mortality after amputation is influenced by various circumstances which are quite independent of the skill of the operator, the most important being the *age*, *constitutional condition*, and *sex* of the patient, his *hygienic surroundings* before and after the operation, the *nature of the lesion* for which amputation is performed, the *period of operation*, and the *part of the body* involved. A few remarks upon each of these points will conclude what I have to say as to the causes of death after amputation.

AGE OF PATIENT.—Amputations in children are usually successful. The remarkable case of synchronous amputation of the hip and leg, which I have recorded on page 591, would not have ended in recovery had the patient been an adult. Statistics showing the effect of age in determining the results of amputations have been collected by several writers, among whom I may particularly mention M. Malgaigne, of Paris, the late Mr. Callender, Mr. Holmes and Mr. Golding-Bird, of London, Dr. Gorman, of Boston, and Dr. Morton, of Philadelphia. The last-mentioned surgeon,[2] from an analysis of 982 cases of amputation treated in the Pennsylvania Hospital during 50 years, from 1830 to 1879, gives the following Table showing the figures bearing upon this point:—

TABLE SHOWING THE EFFECT OF AGE ON THE RESULTS OF AMPUTATION AT THE PENNSYLVANIA HOSPITAL.

	Cured.	Died.	Total.	Mortality per cent.
From 1 to 10 years, there were	70	11	81	13+
" 10 " 20 " " "	218	40	258	15+
" 20 " 30 " " "	220	75	295	25+
" 30 " 40 " " "	132[3]	61	193	31+
" 40 " 50 " " "	63	36	99	36+
" 50 " 60 " " "	24	14	38	36+
Upwards of 60 " " "	10	8	18	44+
Total number of cases	737	245	982	25—

[1] I have not included among the fatal cases that of a woman who, two weeks after her stump had completely healed, aborted of a six months' child, and subsequently died, after the opening (by another surgeon) of a pelvic abscess.

[2] Surgery of the Pennsylvania Hospital, etc., p. 33. By Thomas G. Morton, M.D., and William Hunt, M.D., Surgeons to the Hospital. Philadelphia, 1880.

[3] Clerical error in original Table corrected.

Mr. Golding-Bird[1] has in a similar manner analyzed the results of 559 amputations practised at Guy's Hospital during 15 years, from 1860 to 1874 (inclusive), and shows that they were as follows:—

TABLE SHOWING THE EFFECT OF AGE ON THE RESULTS OF AMPUTATION AT GUY'S HOSPITAL.

	Cured.	Died.	Total.	Mortality per cent.
Patients less than 20 years old	121	33	154	21.4
" from 20 to 40 "	145	78	223	34.9
" over 40 years old	95	87	182	47.8
Total number of cases	361	198	559	35.4

Dr. Gorman's[2] statistics, derived from the practice of the Boston City Hospital, give the results of 285 terminated cases of amputation in persons whose age was ascertained. The results are shown in the following Table:—

TABLE SHOWING THE EFFECT OF AGE ON THE RESULTS OF AMPUTATION IN THE BOSTON CITY HOSPITAL.

	Cured.	Died.	Total.	Mortality per cent.
Patients less than 20 years old	50	22	72	30.5
" from 20 to 40 "	94	47	141	33.3
" over 40 years old	40	32	72	44.7
Total number of cases	184	101	285	35.4

Mr. Holmes's statistics[3] are derived from the practice of St. George's Hospital, and embrace 500 cases. I have re-arranged his table so as to make it correspond in form with those which I have already given.

TABLE SHOWING EFFECT OF AGE ON RESULTS OF AMPUTATION AT ST. GEORGE'S HOSPITAL.

	Cured.	Died.	Total.	Mortality per cent.
Patients less than 5 years old	4	1	5	20.0
" between 5 and 10 years old	18	2	20	10.0
" " 10 " 15 "	33	4	37	10.6
" " 15 " 20 "	53	15	68	22.6
" " 20 " 30 "	90	30	120	25.0
" " 30 " 40 "	57	38	95	40.0
" " 40 " 50 "	46	29	75	31.3
" " 50 " 60 "	25	26	51	50.9
" " 60 " 70 "	12	11	23	47.9
" over 70 years old	4	2	6	33.3
Total number of cases	342	158	500	31.6

Mr. Holmes particularly points out, in regard to these cases, that two of the three deaths in patients less than 10 years of age were totally unconnected

[1] Guy's Hospital Reports, 3d s., vol. xxi. p. 253.
[2] Medical and Surgical Reports, Second series, 1877, p. 291. Dr. Gorman's Tables embrace in all 299 cases, but in 3 cases the result was not determined, and in 11 more the age of the patient is not given.
[3] St. George's Hospital Reports, vol. viii. p. 269.

with the operation, and that, on the other hand, the patients over 60 years of age presented more than ordinarily favorable cases—four of the amputations in those over 70 having been of the forearm, and in those between 60 and 70 hardly any of the amputations having been for injury of the lower extremity.

The late Mr. Callender, in 1864, presented to the Royal Medical and Chirurgical Society of London,[1] statistics of 358 amputations performed during ten years at St. Bartholomew's Hospital. The deaths at different ages in 227 of these cases, are shown in the following Table:—

TABLE SHOWING EFFECT OF AGE ON RESULTS OF AMPUTATION AT ST. BARTHOLOMEW'S HOSPITAL.

	Cured.	Died.	Total.	Mortality per cent.
Patients less than 10 years old	8	0	8	0.0
" between 10 and 20 years old	50	3	53	5.6
" " 20 " 30 "	46	13	59	22.+
" " 30 " 40 "	26	7	33	21.2
" " 40 " 50 "	23	13	36	36.1
" " 50 " 60 "	16	9	25	36.0
" " 60 " 70 "	4	3	7	42.8
" " 70 " 80 "	1	5	6	83.3
Total number of cases	174	53	227	23.3

M. Malgaigne's figures[2] embrace 560 cases, of which 299 terminated fatally.

TABLE SHOWING THE EFFECT OF AGE ON RESULTS OF AMPUTATION IN PARISIAN HOSPITALS.

	Cured.	Died.	Total.	Mortality per cent.
Patients less than 5 years old	2	3	5	60.0
" between 5 and 15 years old	44	22	66	33.3
" " 15 " 20 "	45	36	81	44.4
" " 20 " 35 "	91	102	193	52.8
" " 35 " 50 "	50	76	126	60.3
" " 50 " 65 "	20	50	70	71.4
" more than 65	9	10	19	52.6
Total number of cases	261	299	560	53.3

My own Table tells a similar tale of mortality increasing with advancing years; the larger mortality between the ages of 20 and 30 than between those of 30 and 40, is explained by the circumstance that the cases in the former category embraced two fatal amputations at the hip-joint, and one fatal (intermediate) amputation at the shoulder-joint.

[1] Transactions, vol. xlvii. p. 75.

[2] Archives Générales de Médecine, Mai, 1842, pp. 59, 61.

TABLE SHOWING EFFECT OF AGE IN ONE HUNDRED CASES OF AMPUTATION.

	Cured.	Died.	Total.	Mortality per cent.
Patients less than 10 years old	7	0	7	0.0
" between 10 and 20 years old	26	2	28	7.1
" " 20 " 30 "	15	8	23	34.7
" " 30 " 40 "	13	5	18	27.7
" " 40 " 50 "	5	5	10	50.0
" more than 50 "	4	6	10	60.0
" of uncertain age; "adults"	2	2	4	50.0
Total number of cases	72	28	100	28.0

In order to show the correspondence with each other of these statistics derived from different sources, I have compiled the two following tables, showing (1) the percentage of mortality at the three periods of life: under 20 years, from 20 to 40, and over 40—the classification adopted by Mr. Golding-Bird; and (2) the percentage of mortality before and after 30 years of age—the division adopted by Mr. Holmes:—

TABLE SHOWING PERCENTAGE OF MORTALITY AT DIFFERENT AGES.[1]

	Whole number of cases.	Mortality below 20 years, per cent.	Mortality between 20 and 40, per cent.	Mortality over 40 years, per cent.	General death-rate, per cent.
Pennsylvania Hospital	982	15.0	27.8	37.4	25.—
Guy's Hospital	559	21.4	34.9	47.8	35.4
St. George's Hospital	500	16.9	31.6	43.8	31.6
St. Bartholomew's Hospital	227	4.9	21.7	40.5	23.3
Boston City Hospital	285	30.5	33.3	44.7	35.4
Author's cases[2]	96	5.7	31.7	55.0	27.+
Total number of cases	2649	16.7	30.1	43.4	29.4

TABLE SHOWING PERCENTAGE OF MORTALITY BEFORE AND AFTER THIRTY YEARS OF AGE.[3]

	Whole number of cases.	Mortality below 30 years, per cent.	Mortality over 30 years, per cent.	General death-rate, per cent.
Pennsylvania Hospital	982	19.8	34.2	25.+
St. George's Hospital	500	20.8	42.4	31.6
St. Bartholomew's Hospital	227	13.3	34.5	23.3
Author's cases[4]	96	17.2	42.1	27.+
Total number of cases	1805	19.2	37.4	26.7

These Tables, the figures of which are sufficiently large to afford information of value, show, it seems to me, very conclusively, the influence of age on the results of amputations; they show (1) that in persons less than twenty years old, the operation is a comparatively safe one, but that in patients from twenty to forty, it is nearly *twice*, and in those over forty, not far from *three*

[1] M. Malgaigne's statistics do not give the ages in such a way as to be included in this Table.
[2] Age in 4 cases not stated.
[3] M. Malgaigne's, Mr. Golding-Bird's, and Dr. Gorman's Tables do not show how many patients were under and how many over thirty years of age.
[4] Age in 4 cases not stated.

times as apt to be followed by death as during the earlier period; and (2) that in persons more than thirty years of age, amputation is almost *twice* as fatal as in those who are younger.

Constitutional Condition.—The influence of pre-existing constitutional affections on the results of injuries and surgical operations in general, has been forcibly set forth by Prof. Verneuil in a preceding article of the present volume (page 307), and the same lesson has been taught by Dr. Brinton in his remarks on Operative Surgery in General (page 463). It remains for me therefore, in this place, merely to adduce certain particular illustrations of the truth of these doctrines as applied to amputations. Mr. Birkett[1] has recorded the results of 167 single amputations, mostly performed by himself in the wards of Guy's Hospital. Of the whole number of cases, 53 proved fatal, 10 dying from the immediate effects of the injuries for which the operation was performed, and 22 (or more than half of the remainder) being proved by post-mortem examination to have been the subjects of chronic disease of the viscera, while in fifteen more the patients' powers of nutrition were evidently impaired before the operation. Mr. Holmes, in his two papers,[2] has recorded 500 cases, of which 148 proved fatal: in 33 of these, the patients' death was inevitable, resulting from causes unconnected with the operation; and in 57 more, death, though probably not inevitable, was mainly due to visceral disease or other morbid conditions existing prior to the amputation. Mr. Bryant's Table of 300 cases[3] shows that well-marked visceral disease was the cause of death in 13 per cent. of all fatal cases, and in Mr. Callender's Tables of 358 cases,[4] the mortality from the same cause was over 16 per cent., while Dr Chevers, in his Inquiry into the causes of death after injuries and surgical operations (not exclusively amputations),[5] found that of 153 fatal cases, the kidneys were markedly diseased in at least 72, the liver and spleen also being often affected, and that "in a rather large proportion of these cases, the disease of the liver, spleen, and kidneys had evidently existed for a very considerable time previous to the patient's receiving the wounds or injuries which became the apparent primary causes of death."

Sex.—The influence of visceral disease upon the mortality of amputations, is, of course, largely concerned in rendering the operation more fatal among adults than among children—healthy viscera being the rule in childhood; and the same influence is no doubt shown in the slightly greater risk in persons of the male than in those of the female sex—men, at the period of life at which most amputations are performed, being, from their habits and modes of living, probably more apt to be the subjects of visceral disease than women of the same age. This point may be illustrated by Dr. Steele's Tables of 507 cases of amputation in Guy's Hospital during the fifteen years from 1854 to 1868.[6] The mortality among males was 37.7 per cent., but among females only 21.5 per cent. In Malgaigne's 560 cases[7] of major amputation derived from various French hospitals, the male mortality was over 55 per cent., the female less than 47 per cent.; and in Trélat's 1144 cases,[8] also derived

[1] Guy's Hospital Reports, 3d s., vol. xv. p. 562.
[2] St. George's Hospital Reports, vol. i. p. 291, and vol. viii. p. 269.
[3] Medico-Chirurgical Transactions, vol. xlii. p. 67.
[4] Ibid., vol. xlvii. p. 75.
[5] Guy's Hospital Reports, 2d s. vol. i. p. 78.
[6] Guy's Hospital Reports, 3d s. vol. xv. p. 600. I have not utilized Dr. Steele's statistics as to the effects of *age*, because his Tables are overlapped by those of Mr. Golding-Bird, which are somewhat larger.
[7] Archives Générales de Médecine, Mai, 1842, p. 57.
[8] Bulletin de l'Académie Impériale de Médecine, tome xxvii. p. 591.

from French hospitals at a later period, the male mortality was 48.2 per cent., and the female but 35.5 per cent. The same thing is shown, on a smaller scale, by my own Table—the mortality in the male sex having been 28.5 per cent., and in the female sex only 22.2 per cent. But in St. Bartholomew's Hospital,[1] and in the Pennsylvania Hospital[2] (where, however, comparatively few women have submitted to amputation), the mortality has been larger among them than in persons of the male sex.

TABLE SHOWING THE RELATIVE MORTALITY AFTER AMPUTATION IN THE TWO SEXES.

Authority.	Whole No. of cases.	Males.			Females.			Whole number.		
		Cured.	Died.	Mort. per ct.	Cured.	Died.	Mort. per ct.	Cured.	Died.	Mort. per ct.
Malgaigne	560	200	245	55.+	61	54	46.9	261	299	53.3
Trélat	1144	470	438	48.2	152	84	35.5	622	522	45.6
Steele	507	252	153	37.7	80	22	21.5	332	175	34.5
Callender	227	134	37	21.6	40	16	28.5	174	53	23.3
Morton	982	704	231	24.7	31	16	34.+	735	247	25.—
Author	100	65	26	28.5	7	2	22.2	72	28	28.0
Total number of cases	3520	1825	1130	38.2	371	194	34.3	2196	1324	37.6

HYGIENIC SURROUNDINGS OF PATIENTS.—It is, of course, easy to understand that cases of amputation, as all other surgical cases, should result more favorably when treated in clean and well-ventilated buildings, and when the patients are carefully nursed and suitably nourished after the operation, than when this is practised in foul and close apartments, and the patients neglected and perhaps half starved afterwards. It was no doubt owing to a positive disregard of ordinary hygienic precautions that amputation was formerly such a fatal operation in the Parisian Hospitals, when, according to the statistics of Malgaigne[3] and Trelat,[4] almost every other patient who lost a limb died. But more than this, not only do the surroundings of the patient at the time of, and after the operation, greatly influence the result, but the circumstances under which he has been placed before the operation have likewise a very decided influence in determining its favorable or unfavorable issue. Some years since, the late Sir J. Y. Simpson, in his papers on Hospitalism,[5] collected a large number of statistics, and by them proved to his own satisfaction, if not to that of others, that the mortality after amputation in city hospitals was about four times as large as in country practice; but the fact is that patients who have lived in the country, do better after amputations than the inhabitants of cities, even in city hospitals—so that the question again turns upon the constitutional condition of the individual patient, as influenced by the circumstances of his past life, rather than upon anything special to the operation itself, or even to the particular building in which it is performed. This point may be illustrated by the figures given by the late Mr. Callender,[6] of the results of amputations practised by Sir James Paget and himself during the years 1861—1869: while the whole number of cases was 97, with a mortality of 29.8 per cent., the operations on city patients numbered 68, with a mortality of 35.3 per cent., whereas those on country patients numbered 29, with a mortality of only 17.2 per cent. Similarly,

[1] Callender, loc. cit. [2] Morton, loc. cit.
[3] Archives Générales de Médecine, Avril et Mai, 1842.
[4] Legouest, Chirurgie d'Armée, p. 707. Paris, 1868.
[5] Works, vol. ii. p. 289. New York, 1872.
[6] St. Bartholomew's Hospital Reports, vol. v. p. 249.

among 507 cases tabulated by Dr. Steele,[1] from the records of Guy's Hospital, while the mortality of the whole number was 34.5 per cent., the death-rate among 383 patients from London and its suburbs, was 35.7 per cent.; and that among 124 patients from country districts, only 30.6 per cent.

TABLE SHOWING THE INFLUENCE OF PREVIOUS RESIDENCE ON THE RESULTS OF AMPUTATIONS.

	Whole No. of cases.	Aggregate.			City and suburban patients.			Country patients.		
		Cured.	Died.	Mort. per ct.	Cured.	Died.	Mort. per ct.	Cured.	Died.	Mort. per ct.
St. Bartholomew's Hospital .	97	68	29	29.8	44	24	35.3	24	5	17.2
Guy's Hospital . . .	507	332	175	34.5	246	137	35.7	86	38	30.6
Total number of cases	604	400	204	33.7	290	161	35.6	110	43	28.1

Closely connected with this question of "hospitalism," is that of the occurrence of various forms of blood-poisoning, such as *erysipelas*, *pyæmia*, *hospital gangrene*, etc. It was shown by the famous "discussion on pyæmia," before the Clinical Society of London,[2] that these, which are often spoken of as "hospital-diseases," are really, except as far as it depends upon the different constitutional condition of the patients, quite as common in private practice as in the wards of hospitals. And there can be no doubt that, as long ago pointed out by Dr. Chevers,[3] in a large proportion of cases which prove fatal from internal inflammations (under which name our predecessors included what we now recognize as cases of pyæmia and septicæmia), previously existing visceral disease is present, and not only renders the patient peculiarly susceptible to the influence of these affections, but renders their course much more surely fatal than it would be if they occurred in a healthy subject.[4] My own experience agrees entirely with that of Mr. Holmes,[5] that *erysipelas* and *hospital gangrene*, or, as it might better be called, *sloughing phagedæna*, are so rarely the cause of death after amputation that they may practically be disregarded.

Pyæmia, though more often recognized, is, I have no doubt, really a less frequent cause of death after amputation than it was when the principles of hygiene were less regarded in the construction and management of both hospitals and private houses, than they are at present. It is still, however, a very frequent cause of death. In Mr. Bryant's statistics, presented to the Royal Medical and Chirurgical Society of London, in 1859,[6] the deaths from pyæmia after amputation at Guy's Hospital were 33 in number, a mortality of 43.4 per cent. of fatal cases, and 11 per cent. of all cases amputated; but in Dr. Steele's table of amputations in the same hospital from 1861 to 1868,[7] the mortality from the same cause is registered as but 32.7 per cent. of fatal cases, though 12.8 per cent. of all amputated, and in the cases tabulated in the same gentleman's successive annual reports from 1869 to 1878,[8] the mortality from this source is but 23.1 per cent. of fatal cases, and but 7.6 per cent. of all amputated. In Mr. Callender's 358 cases from St. Bartholomew's Hospital,[9] there were 20 deaths from pyæmia, a mortality of 27 per cent. of fatal cases, or 5.5 per cent. of all amputated. In Mr. Holmes's 500

[1] Guy's Hospital Reports, 3d s., vol. xv. p. 637.

[2] Transactions, vol. vii. pp. xlii–cxvii.

[3] Loc. cit., p. 91.

[4] See also Prof. Verneuil's remarks upon Hepatism and Nephrism in the present volume, pp. 326, 327.

[5] St. George's Hospital Reports, vol. viii. p. 296.

[6] Transactions, vol. xlii. p. 67.

[7] Guy's Hospital Reports, 3d s. vol. xv. p. 630.

[8] Loc. cit., vols. xvi–xxiv.

[9] Medico-Chirurgical Transactions, vol. xlvii. p. 75.

cases, however, from St. George's Hospital,[1] there were 76 deaths from pyæmia (existing in one case before the operation), a mortality of 48.1 per cent. of fatal cases, or 15.2 per cent. of all amputated. At the Massachusetts General Hospital,[2] 692 cases have given 42 deaths from pyæmia (23.3 per cent. of fatal cases, or 6.+ per cent. of all amputated), and at the Boston City Hospital,[3] 296 cases have given 23 deaths from pyæmia (21.2 per cent. of fatal cases, and 7.7 per cent. of all amputated). My own table gives a mortality from pyæmia of but 14.3 per cent. of fatal cases, and but 4 per cent. of all amputated.

TABLE SHOWING THE MORTALITY FROM PYÆMIA AFTER AMPUTATION.

	Total cases.	Total deaths.	Deaths from pyæmia.	Mortality per ct. from pyæmia	
				of fatal cases.	of total cases.
Guy's Hospital (Bryant's Table)	300	76	33	43.4	11.0
" " (1861–1868)[4]	302	119	39	32.7	12.8
" " (1869–1878)[4]	562	186	43	23.1	7.6
St. Bartholomew's Hospital	358	74	20	27.+	5.5
St. George's Hospital	500	158	76	48.1	15.2
Massachusetts General Hospital	692	180	42	23.3	6.+
Boston City Hospital	296	108	23	21.2	7.7
Author's cases	100	28	4	14.3	4.0
Total number of cases	3110	929	280	30.1	9.+

The effects of *season* and *weather* upon the results of amputation have been particularly investigated by M. Malgaigne,[5] and by Dr. Addinell Hewson, of Philadelphia,[6] whose conclusions have been already referred to by Dr. Brinton on page 461 of the present volume. It will be sufficient, therefore, in this place, to mention that amputations performed while the barometer was falling were found to be two-and-a-half times as fatal as those performed while the barometer was rising, and that while the thermometer ranged above the mean annual temperature, the mortality was greater than that when it was below, in the proportion of nearly seven to six. M. Malgaigne's investigations led him to believe that for adults, *winter*, and for children, *summer*, was the most favorable season.

There remain to be considered those conditions which are peculiar to amputation as distinguished from other operations, viz., the *nature of the lesion*, the *period of amputation*, and the *part of the body* concerned.

NATURE OF LESION.—Amputations for *disease* are, as a rule, more successful than those for *injury;* amputations for *malignant disease* or for *acute disease* are more fatal than those performed for *chronic disease*, such as caries, necrosis, or chronic suppurative arthritis. Amputations for *deformity*, again, are less successful than those for other non-traumatic causes. In order to show the comparative mortality of amputations for *injury* and of those for *disease*, I have compiled the following table from published statistics of French, English, and American surgeons.

[1] St. George's Hospital Reports, vols. i. and viii.
[2] Chadwick, Boston Medical and Surgical Journal, vol. lxxxvi., 1871. Supplement, p. xix.
[3] Gorman, loc. cit., pp. 292 et seq.
[4] Partial amputations of hand and amputations of fingers and toes omitted.
[5] Loc. cit., p. 63. [6] Pennsylvania Hospital Reports, vol. ii. p. 17.

TABLE SHOWING THE COMPARATIVE MORTALITY OF AMPUTATIONS FOR INJURIES AND FOR DISEASE.

Authority.	Amputations for injury.			Amputations for disease and deformity.			Total amputations.		
	Cases.	Deaths.	Mort. per ct.	Cases.	Deaths.	Mort. per ct.	Cases.	Deaths.	Mort. per ct.
Malgaigne[1]	182	117	64.2	378	182	48.1	560	299	53.3
Trélat[2]	470	261	55.5	568	233	41.+	1038	494	47.5
Golding-Bird[3]	334	157	47.+	525	117	22.2	859	274	31.8
Callender[4]	130	28	21.5	228	46	20.1	358	74	20.6
Butlin and Macready[5]	108	24	22.2	308	51	16.5	416	75	18.+
Holmes[6]	146	66	45.2	354	92	25.9	500	158	31.6
Spence[7]	186	77	41.4	371	73	19.6	557	150	26.9
Chadwick[8]	328	116	35.3	364	64	17.5	692	180	26.+
Gorman[9]	214	90	42.+	82	18	21.9	296	108	36.4
Varick[10]	80	35	43 7	10	5	50.0	90	40	44.4
Norris and Morton[11]	774	209	27.+	208	36	17.3	982	245	25.—
Author[12]	72	24	33.3	28	4	14.2	100	28	28.0
Totals	3024	1204	39.8	3424	921	26.8	6448	2125	32.9

Not only is the mortality less after amputation when practised for disease, than when practised for injury, in the proportion, as shown by the preceding table, of about two in three, but, as already remarked, the result of the operation is more favorable in cases of chronic bone or joint disease—caries, necrosis, etc.—than in cases of acute disease, of malignant disease, or of simple deformity. The mortality of amputations for *expediency* (including both those for deformity and those for tumor), has been particularly investigated by Mr. Bryant and Mr. Golding-Bird, at Guy's Hospital, and their combined statistics[13] show that the death-rate in this class of cases was 26.8 per cent., as compared with a death-rate of 21.1 per cent. in those of chronic disease. Among my own 28 cases of amputation for disease, the only ones which proved fatal were *acute* cases, to wit, two for acute suppurative arthritis of the knee-joint, in adults; one for elephantiasis and sloughing ulcer; and one for popliteal aneurism which had become diffuse. Prof. Spence's statistics of amputation for disease, which embrace between 300 and 400 cases,[14] show that while the mortality of amputation for *chronic* disease was less than 14 per cent., that of amputation for *malignant* disease was over 46 per cent., and

[1] Archives Générales de Médecine, Mai, 1842, pp. 59, 61.
[2] Bulletin de l'Académie Impériale de Médecine, tome xxvii. p. 591. M. Trélat's Tables contain 1144 cases, but in 106 the nature of the lesion is not recorded.
[3] Guy's Hospital Reports, 3d s. vol. xxi. p. 260.
[4] Medico-Chirurgical Transactions, vol. xlvii. p. 80.
[5] St. Bartholomew's Hospital Reports, vol. xiv. Statistical Tables, p. 114.
[6] St. George's Hospital Reports, vol. i. p. 291, and vol. viii. p. 269.
[7] Lectures on Surgery, vol. ii.; Medical Times and Gazette, October 28, 1876; and Edinburgh Medical Journal, November and December, 1879.
[8] Boston Medical and Surgical Journal, vol. lxxxvi., Supplement, 1871. Dr. Chadwick's Tables contain 699 cases, but the result in 7 was undetermined.
[9] Medical and Surgical Reports of the Boston City Hospital, Second series, 1877, p. 291. Dr. Gorman's Tables contain 299 cases, but the result in 3 was undetermined.
[10] American Journal of the Medical Sciences, April, 1881. Dr. Varick's Tables embrace 95 cases, but the nature of the lesion in 5 cases is not recorded.
[11] Pennsylvania Hospital Reports, vol. i. p. 149; American Journal of the Medical Sciences, October, 1870, and April, 1875; and Surgery of the Pennsylvania Hospital, p. 31.
[12] Vide supra, Table, pp. 612–616.
[13] Guy's Hospital Reports, 3d s. vol. xxi. p. 260.
[14] Lectures on Surgery, vol. ii.; Medical Times and Gazette, March 13, 1875, and Oct. 28, 1876; Edinburgh Medical Journal, November and December, 1879.

that of amputation for *acute* disease (principally acute necrosis of the femur) over 83 per cent.

Period of Amputation.—Amputations for injury have been usually divided by surgical writers into *primary* or *immediate*, and *secondary* or *consecutive* operations; but a better classification is that of modern army surgeons, who make a third class—the *mediate*, *intermediate*, or *intermediary*—which, in point of time, find a place between the other two. *Primary amputations* are those done before the development of traumatic fever, a period of twenty-four, forty-eight, or, in some cases in which shock has been much prolonged, even as much as seventy-two hours; *intermediate amputations* are those done during the existence of acute inflammatory symptoms, a period variously estimated at from two to four weeks; and *secondary amputations* are those done after the subsidence of fever and the occurrence of healthy suppuration.[1] It has long been acknowledged by military surgeons that, except as regards operations at the hip or upper part of the thigh, primary give better results than secondary amputations;[2] but the contrary has been very commonly asserted in relation to civil practice. But even if it were true (which it is not) that the death-rate was less after secondary amputations, this would by no means invalidate the propriety of prompt operation in cases which require such interference; for they are, in the first place, of course the most favorable cases, in which conservative treatment is attempted, and a considerable number of them are, moreover, eliminated by death during the intermediate period; so that the cases of patients who survive long enough to submit to secondary amputation, have been, as it were, doubly selected. Intermediate operations are universally acknowledged to give worse results than either primary or secondary, and experience has but served to confirm the opinion advanced long ago by Benjamin Bell, that "unless the operation . . . can be performed soon after the accident, it cannot again be admissible for a considerable time; for whenever a limb has become swelled and inflamed, it can never, but with the utmost danger, be taken off till those symptoms subside."[3]

In order to show the advantages of *primary* amputation in civil as well as in military practice, I have prepared the following Table which contrasts the results of operations for injury done before the onset of inflammatory fever with those done at a later period.

[1] M. Verneuil applies to these three classes of operation the names of *antepyretic*, *intrapyretic*, and *metapyretic*, respectively.

[2] The reader who is interested in reviewing the acrid disputes upon this question in times gone by, will find a good account of them in Malgaigne's well-known paper in the *Archives Générales de Médecine* for April, 1842. See also Mémoires de l'Académie Royale de Chirurgie, tome ii. pp. 199, 322, and tome iv. p. 133. Paris, 1819.

[3] Op. cit., vol. vii. p. 230.

TABLE SHOWING THE COMPARATIVE RESULTS OF EARLY AND LATE AMPUTATIONS FOR INJURY IN CIVIL PRACTICE.

Reporter.	Primary.			Secondary and Intermediate.			Reference.
	Cases.	Deaths.	Mort. per ct.	Cases.	Deaths.	Mort. per ct.	
Malgaigne	49	34	69.4	20	13	65.0	Archives Générales de Médecine, Mai, 1842.
James	64	15	23.4	28	10	35.7	Trans. Prov. Med. and Surg. Assoc., vol. xvii.
South	18	7	38.9	5	2	40.0	Notes to Chelius's Surgery, vol. iii. Philadelphia, 1847.
Laurie	74	39	52.7	43	26	60.5	James, loc. cit.
Steele	169	62	36.7	53	37	69.8	Ibid.
McGhie	180	60	33.3	87	61	70.1	Macleod, Surgery of Crimean War, p. 367. Philadelphia, 1862.
Hussey	50	9	18.0	6	1	16.6	Ibid.
Erichsen	48	18	37.5	43	19	44.2	Science and Art of Surgery, vol. i. p. 121. Philadelphia, 1878.
Parker	40	8	20.0	9	6	66.6	Cooper's Surgical Dictionary, vol. i. p. 121.
Fenwick	71	23	32.4	10	3	30.0	Ibid.
Callender	93	15	16.1	37	13	35.1	Medico-Chirurgical Transactions, vol. xlvii.
Golding-Bird	240	104	43.3	94	53	56.4	Guy's Hospital Reports, 3d series, vol. xxi.
Spence	144	60	41.6	42	17	40.4	Lectures on Surgery, vol. ii.; Med. Times and Gaz., Oct. 28, 1876; and Edin. Med. Journal, Nov. and Dec. 1879.
Buel	37	12	32.4	24	7	29.1	Am. Journ. of Med. Sciences, 1848.
Lente	29	14	48.3	13	7	53.8	Trans. Amer. Med. Association, vol. iv.
Chadwick	241	84	34.9	87	32	36.8	Boston Med. and Surg. Journal, 1871.
Gorman	164	68	41.5	50	21	42.0	Boston City Hospital Reports, 1877.
Varick	75	31	41.3	5	4	80.0	Amer. Journ. of Med. Sciences, 1881.
Morton	656	164	25.0	118	45	38.1	Surgery in the Pennsylvania Hospital. Philadelphia, 1880.
Author	55	16	29.+	17	8	47.+	Supra, p. 612.
Totals	2497	843	33.7	791	385	48.6	

From this Table it will be seen that the statistics of all but five of the twenty authors whom I have quoted, show that primary amputations are the most successful, and that, taking the aggregate cases of the whole twenty, the death-rate of the early operations is but one in three, while that of the late operations is nearly one in two. Putting the figures in another way, the mortality of early is less than that of late operations, nearly in the ratio of two to three, and, comparing this with the preceding Table, it appears that *primary are as much more successful than other traumatic amputations in civil practice, as amputations for disease are than amputations for injury taken all together.* The difference is even more marked than in military practice, as may be seen from the following Table:—

TABLE SHOWING THE COMPARATIVE RESULTS OF EARLY AND LATE AMPUTATIONS IN MILITARY SURGERY.

Reporter.	Primary.			Secondary and Intermediate.			Reference.
	Cases.	Deaths.	Mort. per ct.	Cases.	Deaths.	Mort. per ct.	
Macleod	1047	.374	35.7	594	314	52.8	Notes on the Surgery of the War in the Crimea, p. 367. Philadelphia, 1862.
Legouest	4038	2530	62.6	999	680	68.+	Traité de Chirurgie d'Armée, pp. 705, 706. Paris, 1863.
Otis[1]	4806	821	17.+	2182	644	29.5	Medical and Surgical History of the War of the Rebellion, Part Second, Surgical volume.
Totals	9891	3725	37.6	3775	1638	43.3	

I am not aware of the existence of any statistics to show the comparative mortality of intermediate and secondary amputations in civil practice, and indeed, in civil hospitals, it very seldom happens that limbs are removed during the intrapyretic period. Only twice, in my own experience, have I felt it my duty to resort to intermediate amputation, and in both of these cases the patients succumbed, though perhaps not much sooner than they would have done from the effects of their injuries, complicated as they were by spreading gangrene, had no operation been performed. In military practice the greater gravity of intermediate amputations has been clearly established; thus of the 2182 late operations with 644 deaths, recorded by Dr. Otis, and included in the preceding Table, 1516 were intermediate, with 481 deaths, or 31.7 per cent., and 666 secondary, with 163 deaths, or only 24.4 per cent.

PART OF THE BODY INVOLVED.—There remains to be considered the influence on the result of amputation exercised by the *locality* of the operation, or, in other words, the particular part of the body in which the amputation is performed. In general terms, it may be said that amputations in the *lower* are more serious than those in the *upper* extremity, and that the nearer to the trunk is the seat of operation, the greater is the risk to life. To illustrate these points, I have prepared the following Table, in which is compared the mortality of the four principal amputations, those of the *thigh*, *leg*, *arm*, and *forearm*.

[1] Amputations of upper extremity only.

TABLE SHOWING THE MORTALITY OF AMPUTATION IN DIFFERENT PARTS OF THE BODY.

Authority.	Forearm.			Arm.			Leg.			Thigh.		
	Cases.	Deaths.	Mort. per ct.	Cases.	Deaths.	Mort. per ct.	Cases.	Deaths.	Mort. per ct.	Cases.	Deaths.	Mort. per ct.
Malgaigne[1]	28	8	28.5	91	41	45.+	192	106	55.2	201	126	62.6
Trélat[2]	44	16	36.3	141	60	42.5	418	184	44.+	360	190	52.7
Golding-Bird[3]	84	14	16.6	91	24	26.3	271	97	35.7	370	132	35.6
Callender[4]	64	3	4.6	78	10	12.8	193	61	31.6	233	80	34.3
Holmes[5]	56	7	12.5	51	14	27.4	137	44	32.1	220	81	36.8
Spence[6]	47	11	23.4	42	15	35.7	66	18	27.2	186	64	34.4
Chadwick[7]	68	13	19.1	76	14	18.6	267	66	24.7	236	68	28.8
Gorman[8]	37	5	13.5	52	14	26.9	71	23	32.3	89	48	53.9
Varick[9]	14	2	14.2	15	7	46.6	15	7	46.6	38	19	50.0
Morton[10]	165	18	10.9	157	32	20.3	314	106	33.7	137	46	33.5
Legouest[11]	447	202	45.1	1142	559	48.9	930	478	51.3	1919	1686	87.8
Otis[12]	1748	245	14.+	5327	1273	23.8	2348	611	26.+	1597	1029	64.4
Author[13]	18	5	27.7	21	6	28.5	25	3	12.0	20	8	40.0
Aggregates	2820	549	19.4	7284	2069	28.4	5247	1804	34.3	5606	3577	63.8

From the above Table it appears that while the mortality of amputations of the *forearm* has been less than 20 per cent., or one in five, and that of amputations of the *upper arm* but little over 28 per cent., or one in four, the death-rate of amputations of the *leg* has been more than 34 per cent., or over one in three, and that of amputations of the *thigh* almost 64 per cent., or nearly two in three.

The fact that the gravity of amputation increases as the trunk is approached, is also seen by comparing the results of amputations in different parts of the thigh; the following are the death-rates given by Macleod and Legouest for operations in the upper, middle, and lower thirds respectively:—

	Macleod.	Legouest.
Amputations in the upper third of the thigh	86.8	87.2
" " middle " " . . .	55.3	58.5
" " lower " " . . .	50.0	55.0

Apart from the proximity to the trunk, the particular part of the bone which is divided in an amputation, exercises an influence on the result of the operation, suppurative osteomyelitis and consequent pyæmia being more apt to follow when the *medullary cavity* of a long bone is laid open, than when only the cancellous structure is involved. Thus of 295 cases of pyæmia following amputation, referred to by Otis,[14] 155, or more than 52 per cent., were after amputation through the shaft of the femur.

[1] Archives Générales de Médecine, Avril, 1842, pp. 402–411.
[2] Bulletin de l'Académie Impériale de Médecine, t. xxvii. p. 591, and Legouest, Traité de Chirurgie d'Armée, pp. 722–736. Paris, 1863.
[3] Guy's Hospital Reports, 3d s., vol. xxi. p. 260.
[4] St. Bartholomew's Hospital Reports, vol. v. p. 247.
[5] St. George's Hospital Reports, vol. i. pp. 293–299, and vol. viii. pp. 276–283.
[6] Lectures on Surgery, vol. ii.; Med. Times and Gazette, March 13, 1875, and Oct. 28, 1876; Edinburgh Medical Journal, November and December, 1879.
[7] Boston Medical and Surgical Journal, 1871. Supplement.
[8] Medical and Surgical Reports of the Boston City Hospital, 2d series, 1877, p. 316.
[9] American Journal of the Medical Sciences, April, 1881, p. 438.
[10] Surgery in the Pennsylvania Hospital, etc., p. 32. Philadelphia, 1880.
[11] Traité de Chirurgie d'Armée, pp. 722–736. Paris, 1863.
[12] Circular No. 6, S. G. O. Washington, 1865; and Medical and Surgical History of the War of the Rebellion. Part Second, Surgical volume.
[13] Supra, p. 612.
[14] Circular No. 6, S. G. O. Washington, 1865, p. 43.

SPECIAL AMPUTATIONS OF THE UPPER EXTREMITY.

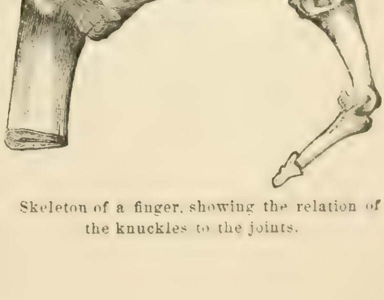
Amputations of the Fingers.

The surgeon is frequently called upon to amputate a part or the whole of a finger, or even several fingers, in cases of injury by gunshot wound or machinery, neglected felon, destruction of the interphalangeal joints by syphilitic disease, etc. As no artificial substitute can possibly replace even for a moderate degree of usefulness, the natural finger, it should be the surgeon's aim to save every portion that can possibly be preserved; hence, if part of a phalanx can be left, this should be done, rather than amputate at the joint above. The only exception to this rule is in the case of the proximal phalanges of the middle and ring fingers; as there is no special flexor tendon for these parts, they are apt, if preserved, to project stiffly, and to rather hinder than assist the usefulness of the rest; hence when, in these fingers, it is necessary to remove all except the proximal phalanges, it is proper to take these away also, and amputate at the phalangeo-metacarpal joint. In the case of the forefinger, however, even part of a phalanx is of value, as affording a point of opposition to the thumb, while in the little finger, the proximal phalanx may be kept in order to give greater symmetry to the hand than it would otherwise possess.

Amputation through a Phalanx may be most conveniently done by the flap method; either by the old plan of Heliodorus (generalized by Ravaton), of making a circular incision down to the bone, and then forming two square flaps by adding longitudinal incisions on either side; or by shaping antero-posterior, semicircular flaps from without inwards. The bone may be divided either with a small saw or with cutting pliers, and the wound accurately closed with three or four points of the metallic suture. Two vessels usually bleed—the digital arteries on either side—and these can commonly be controlled by passing the stitches through their mouths, without the use of ligatures. The whole hand and forearm should be placed upon a well-padded splint, and thus kept at rest for about a week after the operation.

Amputation through either of the Interphalangeal Joints may be readily effected by the single (palmar) flap, or by the double flap method. The circular operation has also been employed in disarticulations of the phalanges, but seems to me to be less advantageous than the flap method in this locality. The most important point to be borne in mind, in these operations, is that the joint is always found *below* the prominence of the knuckle, which is caused by the projection of the *upper* bone, as shown in the accompanying illustration (Fig. 166), suggested by a cut in M. Fort's excellent work on Operative Surgery; in the case of the *last* or *distal* phalanx, the line of the joint is *one line* ($\frac{1}{12}$

Fig. 166.



Skeleton of a finger, showing the relation of the knuckles to the joints.

inch) below the most projecting part of the knuckles; in that of the *middle* phalanx, *two lines* ($\frac{1}{6}$ inch) below; and in that of the *first* or *proximal* phalanx, *four lines* ($\frac{1}{3}$ inch) below the corresponding prominence. It will be found convenient, in disarticulating the phalanx, to employ a slender and rather short knife, with a heavy back. (Fig. 121.)

(1) *Single Flap Operation.*—The flap is usually and preferably taken from the palmar surface (Fig. 167), which affords a firm covering for the stump, and one which at the same time possesses tactile sensibility. Le Dran, however, preferred to take a flap from the side of the finger,[1] while La Roche and Walther took one from the back;[2] the only advantage of this plan was that the resulting cicatrix was less apparent, whence A. Guérin tells us that it was called the "rich man's operation."[3] The palmar flap may be cut either by transfixion or from without inwards, and its formation may constitute either the first or second stage of the operation. If the flap is to be made first, the patient's hand should be held in a supine position, and the knife entered, in the case of the last phalanx a little below, and in that of the middle phalanx on a level with, the palmar crease corresponding to the articulation. The flap should be a little longer than the diameter of the finger, and its width should be as nearly as possible half the circumference; its ends should be rounded, but not too much bevelled, for fear of sloughing. If transfixion is employed (Lisfranc's method), the knife must be kept close to the bone, or the flap will be too narrow. The flap having been formed, the knife is turned with its edge towards the joint, at the upper part of the wound, and, the palmar and lateral ligaments having been divided, disarticulation is effected, and the structures on the back of the finger severed at a single stroke. A better plan is, I think, to attack the joint from its dorsal surface, the hand being held prone, and the finger flexed till the joint has been opened and the lateral ligaments divided; then the knife, placed at the bottom of the wound, is turned flatwise, and, the finger being extended, a flap of sufficient length and breadth is cut by a sawing motion. A. Guérin prefers to make the flap first, by transfixion, as in Lisfranc's method, and then, having pronated the patient's hand, to open the joint and effect disarticulation from the dorsal surface.

Fig. 167.

Amputation of finger by palmar flap method.

(2) *Double Flap Operation.*—Where the surgeon has the opportunity of choosing his mode of amputating through one of the interphalangeal joints, the single palmar flap method gives, I think, the best result; but it may happen, in cases of lacerated wound, etc., that the palmar tissues are deficient, and that the operator must either utilize the structures on the back of the finger, or remove more of the bone than is desirable. Under these circumstances both a dorsal and a palmar flap may be formed, by cutting from without inwards, disarticulation being then effected, and the operation completed, in the manner already described. This, which is the plan recommended by Richerand and Gouraud, seems to me to be in every way preferable to the lateral-flap operation of Maingault.

Amputation of an Entire Finger.—Disarticulation at the metacarpo-phalangeal joint of any of the fingers may be conveniently accomplished by

[1] Dubreuil, Manuel d'Opérations Chirurgicales, p. 86. Paris, 1867.
[2] Ibid.
[3] Op. cit., p. 108.

the oval method of Scoutetten, or, which is better, its modification, the operation "*en raquette*" of Malgaigne; by the double (lateral) flap method; or, in the case of the thumb, by taking a single flap from either the dorsal or the palmar surface. The circular and elliptical operations have also been employed in this situation, but are less desirable than those above mentioned.

(1) *Oval Method.*—The simple oval method, or that of Scoutetten (see Fig. 149, A, page 584), has the disadvantage of often not affording a sufficient covering for the head of the metacarpal bone, and I shall, therefore, describe Malgaigne's modification only, which is not open to this objection. In performing this operation (Fig. 149, B), the hand of the patient should be pronated, and the surgeon begins by making a longitudinal incision of half or three-quarters of an inch over the head of the metacarpal bone; from the lower third of this wound, the knife is carried obliquely downwards on the right side to the interdigital web, then transversely across the base of the finger, and finally obliquely upwards to again join the longitudinal incision. All the tissues down to the bone should be divided, when, the joint having been exposed by a little dissection, the extensor and flexor tendons, and lateral ligaments, are severed, and, disarticulation being thus completed, the sides of the wound are finally brought together in an antero-posterior direction. In the case of the forefinger, however, the point of the oval should be on the radial, and in the case of the little finger, on the ulnar side of the joint; and in these cases the wound should be closed transversely.

(2) *Double Flap Method.*—In this operation (Fig. 168), lateral flaps are cut from without inwards, from either side of the finger which is to be removed. This plan, which is known as Petit's, is I think better than either that of Rossi, who made both flaps by transfixion, or that of Lisfranc, who cut one flap from without inwards, before disarticulating, and the other subsequently from within outwards. Sharp's and Garengeot's methods, in which antero-posterior flaps were employed, are also less desirable than Petit's. The advantage of this operation over the oval method, is that is does not leave a pocket of palmar tissue, in which pus may accumulate; but, on the other hand, the oval method leaves the palm entirely free from the cicatrix, and thus gives at last a better result, though the wound may not heal as quickly as after the flap operation.

Fig. 168.

Amputation of entire finger by double flap method.

(3) *Single Flap Method.*—This operation, which is known as Chassaignac's, seems to be less advantageous than either the oval or double flap method, except in the case of the thumb. The flap may be taken from either the dorsal or palmar surface, the latter plan being, I think, preferable. The joint is opened at the back, and, after disarticulating, the flap is cut from within outwards as in the case of the interphalangeal amputations which have already been described.

Some surgeons advise that the head of the metacarpal bone should be removed, in these amputations, in order to render the loss of the finger less apparent by permitting the others to come more closely together; but what is gained in symmetry, is no compensation for the loss of strength in the hand, thus entailed; there is, moreover, a positive risk in thus opening the deep structures of the palm, suppuration in that part being extremely painful, and apt to extend upwards along the planes of connective tissue in the forearm, thus causing prolonged disability and even endangering life.

Fig. 169.

Amputation of two fingers by oval method.

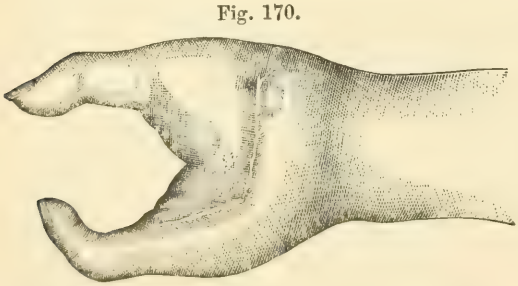
Amputation of two Adjoining Fingers simultaneously, at their metacarpal articulations, may be effected by the circular, oval (*en raquette*, Fig. 169), or elliptical methods, or by taking a flap from the palm (Lisfranc), or from the side of one finger (Chassaignac). A better, if less brilliant, plan is, I think, to amputate each finger separately by whatever method seems best adapted to the particular requirements of the case.

Amputation of the Four Fingers simultaneously, may likewise be done by the circular, elliptical, or palmar-flap methods, the elliptical operation being brobably the best of the three. Here, too, I think that the surgeon will usually do better to forego brilliancy, and remove each finger separately in whatever way may seem best.

Amputations of the Hand.

Partial amputations of the hand are not unfrequently required in cases of laceration by gunshot injury or by machinery, and there are no cases which more than these test the ingenuity and skill of the surgeon in preserving for his patient a useful member. The thumb is of more value than any other part of the hand, and an effort should be made to save every portion that is not hopelessly injured. I have removed all of the hand, except the thumb, through the metacarpus; have saved the thumb and forefinger, removing the rest of the hand quite up to the wrist; and have similarly preserved the thumb and little finger (Fig. 170), or even a single finger, with its metacarpal bone, the whole carpus being removed, and the part of the hand that was left being allowed to be gradually drawn up in contact with the bones of the forearm.

Fig. 170.



Result of partial amputation of hand, the thumb and little finger being preserved.

Amputation of the Thumb through its Metacarpal Bone may be best effected by the oval (*en raquette*) method, the point of the oval being placed on the outer side, and the bone divided at the required point with strong cutting pliers. This operation is very seldom practised.

Amputation of the Thumb with its Metacarpal Bone may be conveniently effected by either the oval (*en raquette*), or the flap method, and, if the latter be employed, the flap may be taken either from the outer (radial) side of the hand, or from the palmar surface.

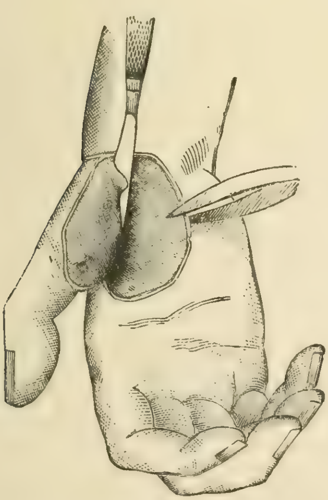
(1) *Oval Method.*—If this operation be practised, the point of the oval should be placed upon the dorsal surface, and should be prolonged upwards as far as the carpo-metacarpal articulation; the sides of the wound are brought to-

gether in a longitudinal direction, and the resulting cicatrix is small and well protected.

(2) *External Flap Method.*—The formation of the flap may be either the first or the last step of the operation. If the former plan is to be adopted, the patient's thumb is forcibly abducted, the hand being supinated for the right and pronated for the left side. The knife is applied to the interdigital web, and made to cut its way upward with a sawing motion until the joint is reached; then the edge of the knife is turned outwards, disarticulation effected, and, the tissues being pushed to the radial side, the flap is made by cutting downwards for a sufficient distance, grazing the bone, and finally outwards. If preferred, the flap may be formed first, either by transfixion or by cutting from without inwards, disarticulation effected from the outer side of the joint, and the tissues of the interosseous space divided as the last step of the operation.

(3) *Palmar Flap Method.*—This variety of amputation, which is known as Chassaignac's, gives a result closely approximating to that of the oval method. In the case of the *right* thumb, the flap is made by transfixion, a strong but slender knife being inserted just in front of the carpo-metacarpal joint, thrust downwards till its point emerges at the interdigital web, and then made to cut its way out opposite the metacarpo-phalangeal joint, thus forming an oval flap from the palm; disarticulation is next effected (Fig. 171), and the ends of the first wound united by cutting through the dorsal tissues from without inwards. In the case of the *left* thumb (Fig. 172) the dorsal incision is made

Fig. 171.



Amputation of *right* thumb by palmar flap method. The flap has been formed, and the knife is effecting disarticulation.

Fig. 172.

Amputation of *left* thumb by palmar flap method.

first, disarticulation effected from behind, and the knife, being thrust in front of the bone, made to cut the palmar flap of the requisite size and shape, as it is brought out with a sawing motion.

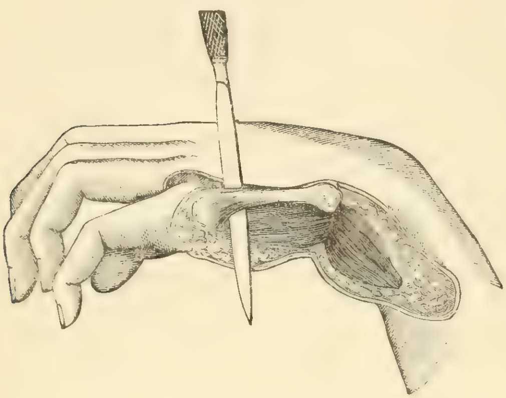
Of these various methods, I decidedly recommend the first (oval method), as, though less brilliant, giving a better result than either of the others.

AMPUTATION THROUGH ONE OR MORE METACARPAL BONES may often be practised with advantage. The *oval method* (*en raquette*) may be conveniently

adopted in these operations, the point of the oval being placed upon the dorsal, or, in the case of the fifth metacarpal, upon the inner (ulnar) surface. In many cases, however, the laceration of the soft parts will be such that no regular procedure can be followed, but the surgeon will be compelled to secure a covering for the bone from any portion of tissue which is uninjured.

Amputation of the Fifth Metacarpal Bone may be effected by either the oval (*en raquette*), or the internal flap method, the former, as in the case of the thumb, being preferable, inasmuch as the resulting cicatrix is smaller and better protected. The point of the *oval* may be placed either on the dorsal, or on the inner (ulnar) surface of the hand, and prolonged upwards as far as the carpo-metacarpal joint. If the *flap* method (Fig. 173) be employed, the flap, which is formed from the tissues on the inner (ulnar) side of the hand, may be made either before or after dividing the interosseous structures, and either by transfixion or by cutting from without inwards.

Fig. 173.



Amputation of fifth metacarpal by internal flap method.

Amputation of the Metacarpal Bone of either the Fore, Middle, or Ring Finger, or of two or more of them simultaneously, may be best done by the *oval* (*en raquette*) method, the point of the oval being placed upon the back of the hand, beginning from a third to half an inch above the line of the articulation. In order to gain more ready access to the joint, Sédillot advises that a short transverse incision should be made at the upper end of the oval, so as to mark out two triangles of tissue, which may then be raised as lateral flaps.

Amputation of the Ulnar portion of the Metacarpus, involving the fourth and fifth metacarpals, or these together with the third, may also be conveniently done by the *oval* method, the point of the oval in this case being placed on the ulnar side. Dorsal and palmar flaps are employed by some surgeons in the performance of this and the preceding form of amputation, but the flap method, in this situation, seems to me more complicated, and in no respect more advantageous, than the simpler oval operation which I have described.

Amputation of the Entire Metacarpus, except the Thumb, is, however, best done by taking a palmar flap, cut from without inwards. An excellent stump is thus produced, and, the thumb remaining, one which will prove of great value to the patient.

Amputation of the Entire Metacarpus, including the Thumb, and Amputation between the two rows of the Carpus, may both be effected by either the circular, elliptical, or antero-posterior flap method. Neither of these operations, however, presents any particular advantage, and both seem to me less desirable than amputation at the wrist, suppuration being apt to occur in the inter-carpal joints, when they have once been opened, and necrosis of the carpal bones often following, and of course delaying recovery.

Excision may be sometimes substituted for amputation of a metacarpal bone, when the finger itself is not injured, but such an operation is not usually very satisfactory. Prof. Joseph Pancoast has successfully adapted a finger which had lost its metacarpal bone, to another metacarpal bone which had, in turn, lost its finger. After all amputations of the hand, as after those of the fingers, the part should be kept upon a splint until the deep parts of the wound have united.

The *risk* of amputation below the wrist is very slight. I have kept no record of my own finger amputations, but do not recall any which have terminated unfavorably. Thirteen cases of partial amputation of the hand, of which I have notes, all ended in recovery. The following Table exhibits the mortality of these operations in hospital and army practice; the death-rate of finger amputations is seen to be but about one in thirty, and that of amputations through the hand, about one in fifteen.

TABLE SHOWING THE MORTALITY OF AMPUTATIONS OF THE FINGERS AND PARTIAL AMPUTATIONS OF THE HAND.

Authority.	Fingers or Thumb.			Partial of Hand.		
	Cases.	Deaths.	Mortality per cent.	Cases.	Deaths.	Mortality per cent.
Malgaigne[1]	165	15	9.+	9	1	11.1
Legouest[2]	320	45	14.+	53	21	39.6
Otis[3]	5739	129	2.2	950	50	5.+
Morton[4]	...	...	...	58	0	0.0
Author[5]	...	...	...	13	0	0.0
Totals	6224	189	3.3	1083	72	6.6

AMPUTATION AT THE WRIST.

The whole hand may be removed at the radio-carpal articulation, by either the circular, the elliptical, or some variety of the flap method. The resulting stump is usually a very good one, and possesses the advantage of allowing the retention of the motions of pronation and supination, but, on the other hand, is said to be less well fitted than a shorter stump for the adaptation of an artificial hand.

CIRCULAR METHOD.—The back of the hand and forearm having been shaved, if necessary, and the tourniquet adjusted so as to control the circulation through the brachial artery, an assistant grasps the hand and holds it firmly, while the surgeon with his own left hand draws the skin of the forearm upwards, and makes his first incision on a level with the carpo-metacarpal articulation of the thumb and fifth finger, from an inch to an inch and a half, therefore, below the joint of the wrist. As the integuments in this situation are ample, and loosely attached, it is usually possible to retract them sufficiently, after the first incision, by the aid of light touches of the knife, without any regular dissection; when the wrist is reached, the part is held in a position midway between pronation and supination, and the

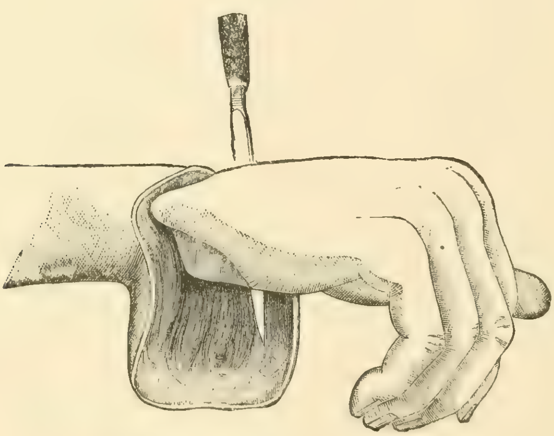
[1] Archives Générales de Médecine, Avril, 1842, pp. 413, 416.
[2] Traité de Chirurgie d'Armée, p. 721. Paris, 1863.
[3] Medical and Surgical History of the War of the Rebellion, Part Second, Surgical volume, p. 1019.
[4] Surgery of the Pennsylvania Hospital, etc., p. 32.
[5] Supra.

joint opened from the radial side. Disarticulation having been effected, the cut vessels are secured (three or four commonly require attention), and the wound is closed transversely.

Elliptical Method.—This is, upon the whole, probably the best operation in this particular situation. The lower segment of the ellipse may be made from either the palmar or the dorsal surface of the hand, the former plan being preferable as giving a firmer covering for the ends of the bones. The patient's hand being supinated, the surgeon begins his incision, with a strong, short-bladed knife, about three-quarters of an inch below the styloid process of the radius, curves it downwards through the tissues of the palm to a point about an inch lower, and then upwards again to three-quarters of an inch below the styloid process of the ulna; the hand is then pronated; and the ends of the first incision joined by another, slightly curved upwards, and crossing the back of the hand about half an inch below the joint. The cuff thus marked out having been dissected upwards as far as necessary, disarticulation is effected from the radial side, and the operation terminated as in the circular method. The wound forms a curved cicatrix on the dorsal side of the stump, the bones being covered by the firm tissues of the palm.

Flap Methods.—Of these, the best is the single palmar flap method (Fig. 174), the flap being cut from without inwards, and the result of the operation

Fig. 174.



Amputation at wrist by palmar flap method.

closely approximating to that of the elliptical method, as just described. The formation of a flap by transfixion, as practised by Lisfranc, is attended with much difficulty, and is now generally abandoned. Another plan is to employ two flaps—either lateral or antero-posterior—but I do not recommend this mode of procedure. A better plan (but still inferior, I think, to either the palmar flap or the elliptical method), is that of Dubrueil, who makes a single external flap, from the tissues around the metacarpal bone of the thumb.

Amputation at the wrist joint appears to be seldom performed either in civil or in military practice; I have myself done it but once, for gunshot injury, in a lad of seventeen who made a good recovery. The death-rate, as shown by the following Table, appears to be unduly high—a circumstance

which is due to the large proportion of cases derived from the records of the French army in the Crimea, in which service amputations of all kinds proved to be of exceptional gravity.

TABLE SHOWING THE MORTALITY OF AMPUTATIONS AT THE WRIST.

Authority.	Cases.	Deaths.	Mortality per cent.	Reference.
Malgaigne . .	16	0	0.0	Archives Gén. de Médecine, Avril, 1842.
Trélat . . .	27	6	22.2	Legouest, Traité de Chirurgie d'Armée, p. 722. Paris, 1863.
Legouest . .	77	36	46.7	Ibid.
Otis . . .	66	7	10.6	Med. and Surg. History of the War, etc.
Aggregates . .	186	49	26.3[1]	

AMPUTATION OF THE FOREARM.

The best operation in this situation is, under ordinary circumstances, the circular, though very good stumps may be made by several of the flap methods. The amputation may be done at any part of the limb, the disadvantages supposed by Larrey to attend division of the tendinous structures at the lower part of the forearm, being more imaginary than real, and there being a positive advantage in making the stump as long as practicable.

CIRCULAR METHOD.—If the limb be conical, as it usually is except in very thin persons, there may be some difficulty in turning up the tegumentary cuff, in the circular operation, when it will be advisable to slit the cuff upon the ulnar side. If the tendons elude division, in amputating at the lower part of the limb, the knife may be slipped beneath them and they may be cut from within outwards. In sawing the bones, the limb should be placed in a position midway between pronation and supination, so that both bones may be divided at the same level. Five or six vessels commonly require ligation, in forearm amputations, and of these the anterior and posterior interosseous are those that give the most trouble, from their tendency to retract between the bones, where it may be difficult to discover them.

FLAP METHODS.—The most brilliant operation is that made by taking *antero-posterior flaps* (see Fig. 150, page 586), the posterior flap being shaped from without inwards, and the anterior being cut either in the same way, or by transfixion, according to the fancy of the operator. I have more than once known consecutive hemorrhage to follow this particular form of operation, apparently from the interosseous artery having been divided obliquely, and as a consequence not being properly secured by the ligature; hence I have been led to prefer, in this situation, either the circular operation or *Teale's method*, in which this complication is more readily avoided. In practising Teale's method (Figs. 151, 152, pp. 587, 588), care must be taken to mark out the flaps by measurement before attempting to cut them, as otherwise, from the conical shape of the limb, the long flap will be apt to be made too narrow at its distal extremity. In any of the flap methods, trouble may be experienced from the tendons projecting beyond their sheaths. Should this occur, each tendon should be separately seized with forceps, drawn down, and cut off at as high a point as possible.

[1] Omitting Legouest's cases, the mortality would be about 12 per cent., which would, I believe, be a fairer statement.

Mixed Methods.—Sédillot makes superficial flaps, and divides the deeper tissues circularly, while on the other hand Richet makes a circular incision through the skin and fascia, and then forms muscular flaps by transfixion. I see no advantage in either of these proceedings over those more commonly adopted.

The *mortality* after amputation of the forearm is, as shown by the Table on page 630, 19.4 per cent., or about one in five. It would appear from Otis's statistics,[1] that the results are slightly more favorable for amputations at the middle of the forearm than for those at either extremity, though among the smaller number of cases embraced in Gorman's Tables,[2] amputations of the middle third proved the most fatal.

Amputation at the Elbow.

This operation appears to have been first performed by the illustrious Ambroise Paré,[3] in the case of a soldier whose arm became gangrenous after a severe wound from an arquebuse. The patient was attacked with tetanus fifteen days after the operation, but eventually made a good recovery.

Amputation at the elbow may be performed by either the elliptical, the circular, or one or other variety of the flap method, the first-named plan being, I think, upon the whole the best.

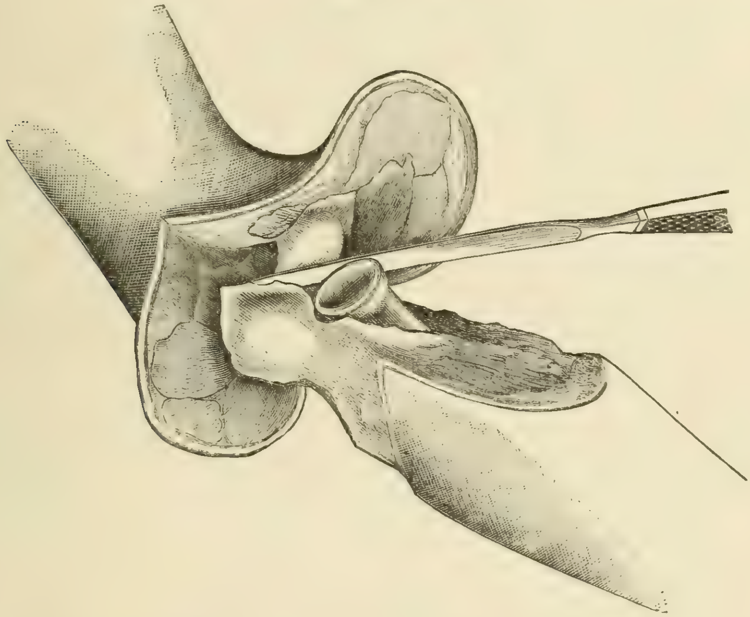
Elliptical Method.—The lower segment of the ellipse should be placed upon the back of the forearm (see Fig. 148, page 583), where the tissues, though not very thick, are resisting, and accustomed to support pressure. The arm being semiflexed, the point of the knife is entered nearly an inch below the internal condyle of the humerus, curved upwards over the front of the forearm nearly to the line of the joint, and downwards again to a point an inch and a half below the external condyle; the arm being then forcibly flexed, the ellipse is completed on the back of the forearm by a curved incision passing nearly three inches below the tip of the olecranon. The cuff thus marked out is rapidly dissected upwards as far as necessary, when the muscles of the front of the forearm are cut about half an inch below, and the ulnar nerve as far above the joint, and disarticulation is effected from the outer side. Some surgeons leave the olecranon *in situ*, sawing across its base; but it is apt to become necrosed under these circumstances, and, altogether, I see no advantage to be gained by its retention. The vessels requiring ligation, in this operation, are the brachial—or the radial and ulnar, according to the exact line of the deep incision—with some smaller anastomotic branches. The wound is closed transversely, forming a small curved cicatrix in front of the bone, which is well covered.

Circular Method.—In this operation, which also makes a good stump, the first incision is placed two and a half or three inches below the line of the joint. It is better not to cut through the muscles, but to adopt Velpeau's plan, and dissect up the cuff of integument to the necessary height, and then effect immediate disarticulation. The olecranon should be removed in this as in the elliptical operation.

[1] Medical and Surgical History, etc., Second Part, Surgical volume, p. 967.
[2] Medical and Surgical Reports of the Boston City Hospital, Second series, 1877, pp. 299, 300.
[3] Op. cit., t. ii. p. 233.

Flap Methods.—Two varieties of flap operation are practised in this situation: the *anterior flap method* of Brasdor, Dupuytren, and Sédillot, and the *external flap method* of Alphonse Guérin. Of the two, the latter (Fig. 175)

Fig. 175.



Amputation at right elbow by external flap method.

seems to me the best, but either is, I think, less desirable than the operations already described. In performing Guérin's operation, the limb is held in a semi-prone position, and the surgeon, introducing the point of his knife in the middle line of the forearm, about an inch below the bend of the elbow, cuts downward for a short distance and then transfixes the limb, grazing the radius on the outer side as he does so, with the blade of his instrument. An external flap, from two to two and a half inches in length, is then cut with a sawing motion, and the tissues on the inner side of the limb next divided by a curved incision, convex downwards. Disarticulation is effected by opening the joint from its outer side.

The stump which results from amputation at the elbow-joint is an admirable one, and the operation should, I think, always be preferred to removal of the limb at a higher point. It is somewhat difficult to estimate the death-rate of this operation; it does not appear to have been often resorted to in civil practice—I have myself done it but once—and Malgaigne's and Trélat's combined statistics, as quoted by Legouest, give but nine cases with three deaths. Mr. Bryant speaks of six successful cases in his own practice. Legouest reports 41 cases from the French army in the Crimean war, with 21 deaths, but Chenu (as quoted by Otis)[1] gives the figures for the same service as 79 cases with 52 deaths. The same writer tabulates, in all, 133 elbow amputations for gunshot injury with 101 deaths—a frightful mortality of nearly 76 per cent. But, on the other hand, 39 terminated cases in the late war in this country, gave but 3 deaths, or less than 8 per cent.

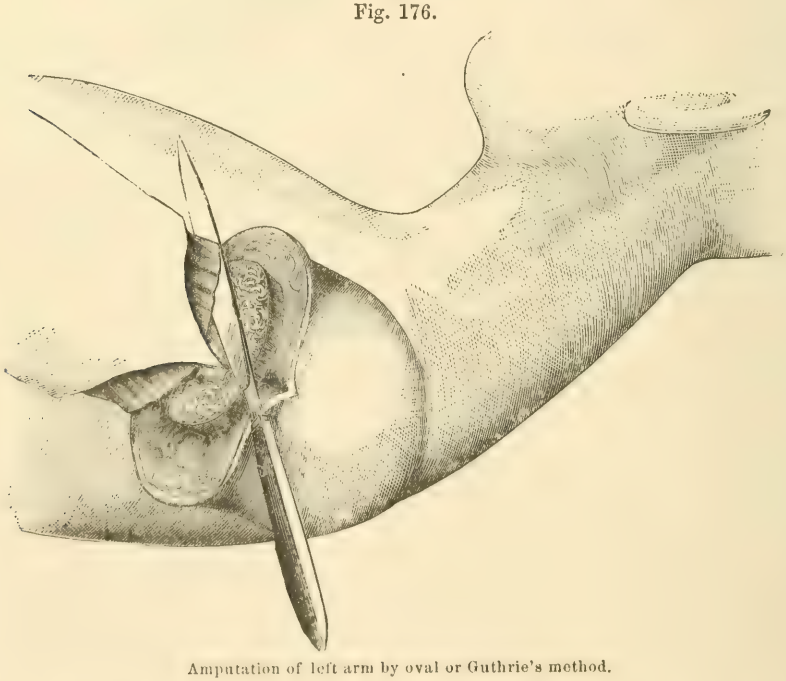
[1] Medical and Surgical History, etc., Part Second, Surgical volume, p. 910 (Note).

Amputation of the Arm.

The humerus is placed so nearly in the middle of the arm, that, in this situation, an excellent covering, both of skin and muscle, can be obtained by any mode of amputating that the surgeon happens to fancy. My own preference, in arm amputations, is for the circular operation, plain or modified, or for the oval method. The arm, however, is often considered the typical locality for the employment of the double flap method, and I have myself, on more than one occasion, adopted with advantage the rectangular flap method of the late Mr. Teale. If the arm is to be amputated near the shoulder, there may not be sufficient space for the adjustment of the tourniquet in the usual manner. Under these circumstances, if the limb be drawn out at a right-angle with the body, so as to make the head of the humerus project into the armpit, the axillary artery may be readily controlled by applying a rather thick and broad compress, and placing the tourniquet plate over the acromion process of the scapula; or compression may be made upon the subclavian artery, where it crosses the first rib, by means of a wrapped key entrusted to a careful assistant.

Circular Method.—This is the operation to which I give the preference in amputating at or below the middle of the arm. (See Fig. 146, page 581.) If the limb be slender, sufficient retraction of the skin can ordinarily be

Fig. 176.



Amputation of left arm by oval or Guthrie's method.

obtained without formally dissecting and turning up the cuff, but under opposite circumstances this must be done, and it will then be convenient to slit the cuff by a longitudinal incision on the outer side. When the muscles are divided, it will be found that the biceps retracts much more than the others; hence, unless this have been purposely cut long, a second sweep of the knife should be made, to insure that all are severed upon the same level. Six

or seven ligatures are usually required in a primary, and sometimes as many as fifteen or even more, in a secondary amputation in this locality. The possible occurrence of a high division of the brachial artery must always be borne in mind.

Oval Method.—This, which is sometimes known as Guthrie's method, is particularly adapted for amputations in the upper part of the arm—above the insertion of the deltoid muscle. The point of the oval (*en raquette*) is placed upon the outer side of the arm (Fig. 176), beginning about two inches below the acromion process of the scapula; the lateral branches are slightly curved, with their convexity outwards and downwards, and the posterior branch is usually made first; the base of the oval, which is placed on the inner side of the arm, and in forming which the main artery is divided transversely, may be cut either by transfixion or without inwards, according to the preference of the operator. This operation is easily executed, and affords an admirable stump.

Flap Methods.—Sabatier employed a single, square, external flap; Vermale, double lateral flaps; and Langenbeck and Klein, double antero-posterior flaps. Sédillot employs his favorite "mixed method," making superficial lateral flaps by transfixion, and dividing the muscles circularly. Teale's and Lister's methods are also perfectly applicable in this situation. The chief precaution to be observed in amputating by any of the flap methods, is to make sure that the musculo-spiral nerve is completely divided before applying the saw. Provided that enough tissue has been preserved to make a good covering for the bone, the surgeon can hardly fail to obtain a satisfactory stump, by whatever method he may employ.

The mortality after amputation through the arm, as shown by the Table on page 630, is 28.4 per cent., or about two in seven. Special attention was directed by the late Dr. Otis[1] to the exceptional gravity of amputations in the *lower third* of the arm, in which situation he found the death-rate of the operation to be 35.2 per cent., as compared with one of 22.6 per cent. for the *upper third*, and one of only 19.6 per cent. for the *middle third* of the limb. This remarkable difference, for which no adequate explanation has yet been suggested, is still more observable in Gorman's statistics, derived from civil practice,[2] in which the respective death-rates were 22.7 per cent. for the *upper*, 21.+ per cent. for the *middle*, and no less than 45.4 per cent. for the *lower third* of the arm.

Amputation at the Shoulder.

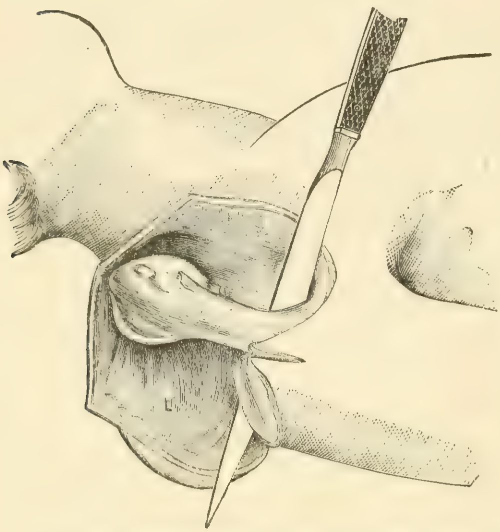
This operation was described by the ancients, but does not appear to have been actually put in practice until the early part of the eighteenth century, unless we recognize as a shoulder-joint amputation the famous case of gangrene, recorded by the Abbé de la Roque,[3] in which, when about to saw through the humerus, the surgeon found the bone loose, and pulled it out of its socket. It is uncertain to whom the credit of first having intentionally performed a shoulder-joint amputation actually belongs, the younger Le Dran[4] and the younger Morand[5] having both claimed it for their respective fathers.

[1] Medical and Surgical History, etc., Part Second, Surgical volume, pp. 739, 806, 823.
[2] Medical and Surgical Reports of the Boston City Hospital, Second series, 1877, pp. 295–297.
[3] Journal de Médecine, 1686; Velpeau, op. cit., t. ii. p. 448.
[4] Traité des Opérations de Chirurgie, p. 571. Paris, 1742.
[5] Opuscules de Chirurgie, t. ii. p. 212. Paris, 1768.

Le Dran's operation, which was done in 1715, certainly excited the most attention, for it is fully described by Garengeot[1] and La Faye,[2] who give no account of Morand's case, though in his notes to Dionis,[3] La Faye undoubtedly attributes to the latter the priority. This operation has been performed in a great variety of ways—Sédillot enumerates at least twenty, Velpeau thirty, and Lisfranc thirty-six—but I shall describe only three methods: the oval, or Larrey's; the external flap method, or Dupuytren's; and the antero-posterior flap method, or that of Lisfranc.

Oval Method.—The circulation being controlled by compressing the subclavian artery upon the first rib with a wrapped key, boot-hook, or tourniquet handle, the point of a strong and not very large knife is introduced below and a little in front of the acromion process of the scapula, and a deep incision is made in a longitudinal direction, and reaching about an inch and a half below the neck of the humerus, the length of the first cut being thus about three inches. (Fig. 177.) From about, or a little below, the middle of this incision, the knife is then carried obliquely downwards in front and behind, making the lateral branches of the oval, which branches, if the limb be muscular, should be somewhat curved, with their convexity downwards. These lateral incisions (of which, if the circulation be well controlled, the posterior should be made first, but otherwise the anterior, on account of the large size of the posterior circumflex artery) should terminate at the points at which the anterior and posterior axillary folds end in the tissues of the arm. The lips of the wound being then loosened from the bone by a few rapid strokes of the knife, the surgeon proceeds to effect disarticulation, first rotating the arm forcibly outwards while he divides the subscapular muscle which is thus rendered tense, next cutting through the capsule of the joint and the tendon of the long head of the biceps, and finally, while the arm is forcibly rotated inwards, severing the infra-spinatus and the supra-spinatus muscles, and the teres minor. The knife is then slipped crosswise behind the neck of the bone, and at the same moment an assistant grasps the axillary artery behind the knife, the vessel being always found in the first muscular interspace from the anterior axillary fold; the lateral incisions are then connected by a transverse cut through the tissues of the arm, from within outwards. The vessels are then quickly tied, the brachial and the subscapular arteries being the largest which require attention, and the sides of the oval are brought together so as to make a linear wound, the direction of which corresponds with the long axis of the patient's body. The appearance of the stump resulting

Fig. 177.



Amputation at right shoulder by oval, or Larrey's method.

[1] Traité des Opérations de Chirurgie, t. iii. p. 456. Paris, 1731.
[2] Mémoires de l'Académie Royale de Chirurgie (an 1740), t. ii. p. 166. Paris, 1819.
[3] Cours d'Opérations de Chirurgie, p. 758. Paris, 1740.

from an amputation by this method is seen in Fig. 178, from a photograph of a lad under my care many years ago at the Episcopal Hospital.

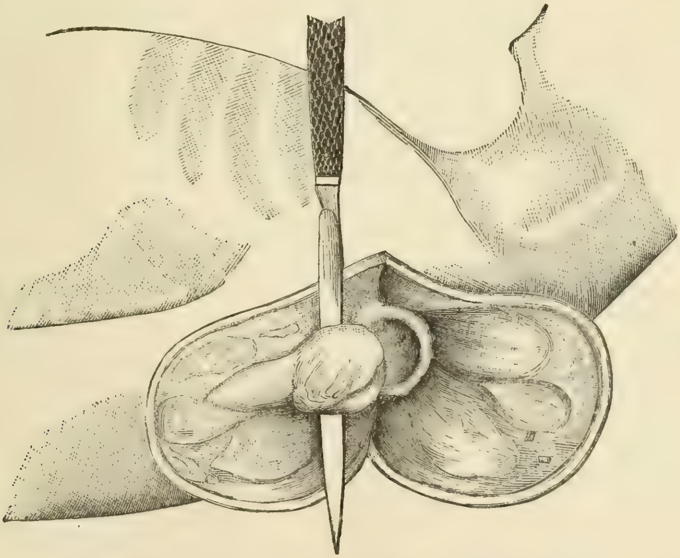
Mr. Spence has modified this operation by making the first (longitudinal) incision much longer, as if for excision of the caput humeri, and making the branches of the oval more nearly transverse than in Larrey's method.

Fig. 178.

Result of shoulder-joint amputation by Larrey's method.

External Flap Method.—This method was first described in print by M. Grosbois, who claimed it as his own in a thesis published in 1803, but it is believed by Velpeau, Sédillot, and other French authorities, to have really originated with Dupuytren, whose name it commonly bears, and who, we are told,[1] practised it with "great dexterity," on the occasion of the "concours" for the chair of operative surgery (February 15, 1812).[2] It is a modification of the early operation of Le Dran and La Faye. The principal flap is an external, or, more strictly, a postero-external one, which embraces the thickness of the deltoid muscle (Fig. 179). Grasping this part with his left hand, the surgeon enters the point of his

Fig. 179.

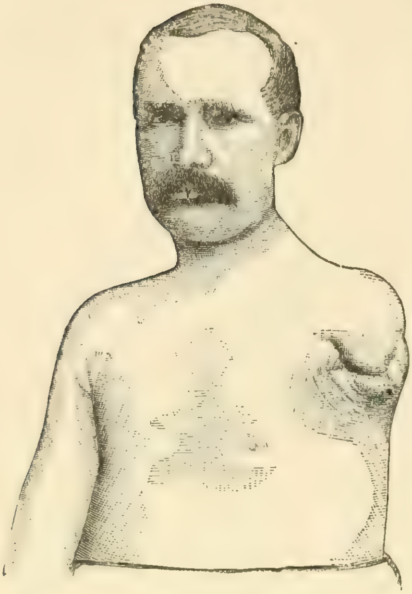


Amputation at left shoulder by external flap, or Dupuytren's method.

knife about an inch in front of the acromion process of the scapula, and pushing it directly across the joint and its capsule, brings it out at the posterior axillary fold; the knife is then made to cut at first directly downwards, and then outwards and backwards, with a sawing movement, forming a large flap which is taken in charge and held out of the way by an

[1] Dictionnaire des Sciences Médicales, t. i. p. 496. Paris, 1812.
[2] Id. op., Biographie Médicale, t. iii. p. 556. Paris, 1821.

Fig. 180.



Result of shoulder-joint amputation by Dupuytren's method.

assistant. Disarticulation is then effected as in the oval operation, by rotating the arm successively inwards and outwards so as to render the muscles tense before they are cut, and the operation is terminated by slipping the knife behind the bone, and cutting a short flap which contains the brachial artery. The same precautions against hemorrhage should be observed here which were described in the account of Larrey's operation.

A modification and, I think, an improvement of this method, originally practised by Cline, and first described in this country by Dr. J. A Smith, of New York, in a letter to Dorsey,[1] consists in cutting a deltoid flap of curved outline from without inwards, then disarticulating, and finally completing the operation in the way already described. Fig. 180 shows the appearance of a stump resulting from this variety of the operation.

Antero-posterior Flap Method.—This, which is known as Lisfranc's operation, gives a resulting wound not unlike that obtained by the oval method, to which, however, it seems to me to be inferior. It is described by its inventor as his second method.[2] Supposing that it is the left arm which is to be removed, the surgeon, causing it to be held three or four inches away from the body, seizes the shoulder with his left hand, and with his right introduces a long knife on the outer side of the posterior fold of the axilla, in front of the tendons of the latissimus dorsi and teres major, the blade of the knife being pushed along the posterior surface of the humerus and its edge being directed outwards and forwards. The knife is steadily thrust onwards until its point reaches the head of the humerus, when the hand is first raised (to clear the head of the bone), then slightly depressed, and finally raised again and carried outwards, till the point is beneath the triangular space which exists between the caput humeri and the acromion and coracoid processes. Counter-puncturation is next effected by thrusting the point of the instrument through the skin, and a posterior or more strictly a postero-external flap, extending two or three inches below the joint, is then cut from without inwards. This flap is held out of the way by an assistant, while the surgeon slips the knife around the head of the bone from behind forwards, and then cuts an anterior or antero-internal flap, another assistant grasping the artery before it is divided, as in Larrey's method. In amputating the right arm, the anterior flap may be cut first, if the surgeon is ambidextrous, but it is better to use the right hand, standing behind the patient, and making the posterior flap by transfixion from above downwards.

Amputation at the shoulder-joint is in appearance a most formidable operation, and yet its results are upon the whole fairly successful. The

[1] Elements of Surgery, etc. By John Syng Dorsey, M.D., 2d edit., vol. ii. p. 309. Philadelphia, 1818.
[2] Précis de Médecine Opératoire, t. ii. p. 186.

following Table shows the mortality of the operation according to different authorities.

TABLE SHOWING THE RESULTS OF AMPUTATION AT THE SHOULDER-JOINT.

Authority.	Cases.	Deaths.	Mortality per cent.	Reference.
Malgaigne . .	13	10	76.9	Arch. Gén. de Médecine, Avril, 1842, p. 409.
Trélat . . .	27	17	62.9	Legouest, Chirurgie d'Armée, p. 725. Paris, 1863.
Legouest . . .	207	135	65.2	Ibid.
Macleod . . .	173	69	39.8	Surgery of the Crimean War, p. 346. Phila., 1862.
Otis	841	246	29.2	Surgical History of the War, Part Second, pp. 468, 613.
Spence . . .	27	9	33.3	Lectures on Surgery, vol. ii.; Med. Times and Gaz., 1875, 1876; Edin. Med. Journal, 1879.
Golding-Bird . .	11	4	36.3	Guy's Hosp. Reports, Third series, vol. xxi. p. 260.
Butlin and Macready	7	3	42.8	St. Bartholomew's Hosp. Reports, vol. xiv. p. 114.
Morton . . .	30	9	30.0	Surgery of the Pennsylvania Hospital, p. 32. Philadelphia, 1880.
Chadwick. . .	26	11	42.3	Boston Med. and Surg. Journal, May 1, 1871.
Gorman . . .	20	8	40.0	Med. and Surg. Reports of Boston City Hospital, Second series, p. 292.
Author[1] . . .	5	2	40.0	Supra, page 612.
Aggregates . .	1387	523	37.7	

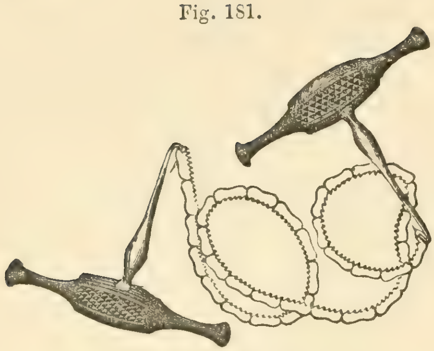
Comparing these figures with those given in the Table on page 630, it is seen that the death-rate of shoulder-joint amputation, which is less than two in five, is not much greater than that of amputation of the leg, and very much less than that of amputation of the thigh.

AMPUTATION ABOVE THE SHOULDER.

This operation, which consists in removing *at the same time* the entire arm together with part or all of the scapula, and perhaps a portion of the clavicle, appears to have been first performed by Cuming, in 1808, though the famous case of the miller, Samuel Wood, whose arm and scapula were torn off by a rope becoming wound around his limb, and who recovered without any bad symptoms, occurred in 1737, and had long been familiar to surgeons.[2] No universally applicable directions can be given for the performance of this operation, the surgeon, in cases of injury, being compelled to use for his flaps whatever tissues are sufficiently sound for the purpose, and the lines of incision varying, in operations for tumors of the part, in accordance with the size and shape of the particular growth concerned. Lisfranc's advice appears to be judicious; that the arm should be first disarticulated, and the axillary vessels secured, and that the scapula should be removed subsequently. This bone may be readily exposed by either a crucial or a T-shaped incision, and its detachment effected, as advised by Fergusson and Pollock, by cutting from below upwards. Separation from the clavicle may be accomplished

[1] Besides the five cases tabulated above, I have twice (unsuccessfully) amputated at the shoulder-joint synchronously with other major amputations. (See Table on page 592.)
[2] Cheselden, Anatomical Tables, Tab. xxxviii. p. 43. Boston, 1796.

Fig. 181.



Chain saw.

either with cutting pliers or with a chain saw. (Fig. 181.)

The gravity of the operation varies, of course, with the extent of bone removed; if this be limited to the acromion, the case is but little more dangerous than an ordinary shoulder-joint amputation, but if the whole or greater part of the scapula be taken away, the risk is very much increased.

Statistical writers have very commonly confused this operation with that of *excision of the scapula*, either without interference with the arm, or subsequent to previous amputation. This operation will be described in a future volume. The annexed Table contains a summary of fifty-one[1] cases to which I have references, which are properly designated as amputations above the shoulder.

TABLE OF AMPUTATIONS ABOVE THE SHOULDER.

No.	Operator.	Result.	No.	Operator.	Result.	No.	Operator.	Result.
1	Asiari	Cured	19	Hamilton	Cured	37	Parise	Died
2	Bland	"	20	Hayward	"	38	Pirondi	"
3	Bower	"	21	Hendry	"	39	Ross	Cured
4	Brice	"	22	Herr	Died	40	Soupart	"
5	Buchanan	Died	23	Hunter	"	41	Syme	"
6	Busch	Cured	24	Jackson	"	42	Tirifahy	"
7	Charles	"	25	Jessop	Cured	43	Twitchell	"
8	Clot	"	26	Langenbeck	Died	44	Watson	"
9	Crosby	"	27	Lewis	"	45	Wheelhouse	"
10	Cuming	"	28	Lund	Cured	46	Whishaw	"
11	Esmarch	"	29	McClellan	"	47	Wood	"
12	Fayrer	Died	30	McGill	Died	48	Id.	"
13	Fergusson	Cured	31	Macleod	"	49	Young	"
14	Id.	Died	32	Mussey	Cured	50	Surg. at Penn. Hospital	"
15	Gaetani Bey	Cured	33	Niepce	"			
16	Gilbert	"	34	O'Grady	"	51	Surg. referred to by Dr. Otis	"
17	Gross	Died	35	Parise	"			
18	Gundrum	Cured	36	Id.	"			

The above 51 cases gave 38 recoveries and 13 deaths, a mortality of only 25.5 per cent. There are besides at least 14 cases on record in which recovery has followed accidental avulsion of the arm and part or all of the scapula,[2] so that if we should take these figures without allowance, we would conclude that the operation was really one of little risk. It is at least sufficiently successful to justify the surgeon in resorting to it in suitable cases.

[1] Velpeau says that Larrey did this operation "several times," and "more than once" with success. (Nouveaux Elements de Médecine Opératoire, t. ii. p. 465.)

[2] Dr. Stephen Rogers, of New York, collected twelve cases, in papers in the American Journal of the Medical Sciences for October, 1868, and the New York Medical Journal for December, 1870. A thirteenth case, recorded by Kathaletzky, is noted in the London Medical Record for Dec. 17, 1873, and a fourteenth is reported by Dr. Ellis-Jones, a Welsh surgeon, in the Lancet for Aug. 20, 1881.

SPECIAL AMPUTATIONS OF THE LOWER EXTREMITY.

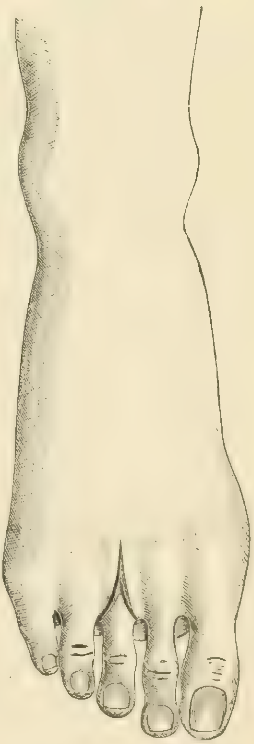
Amputations of the Toes.

Amputation through the Phalanges of the toes is very seldom resorted to, it being almost always better to disarticulate through the interphalangeal or metatarso-phalangeal joint. If the operation were thought necessary, it could be conveniently done by cutting *antero-posterior flaps* from without inwards, and dividing the bone with strong cutting pliers.

Amputation at any of the Interphalangeal Joints is best done by the *plantar flap* method, as in the case of the fingers. The joint is opened from the dorsal surface, and the flap formed, after disarticulation, by cutting from within outwards.

Amputation of a Toe at its Metatarso-phalangeal Joint is more often required than either of the operations described above. It may be done by either the *lateral flap* or the *oval* (*en raquette*) *method* (Fig. 182), the latter plan being the best. The most important point to be remembered is that the interdigital web is placed about half way between the joint and the extremity of the toe, and that hence the articulation is situated higher than it appears to be. The point of the oval should invariably be placed upon the dorsum of the foot—even in the case of the great and fifth toes—so that the cicatrix may not be exposed to friction from the shoe. The knife is entered from half to three-quarters of an inch above the joint, and made to cut first in a longitudinal direction to the line of articulation, and then carried obliquely, first on one side and then on the other, to the edge of the interdigital web, thus forming the branches of the oval, which are eventually joined by a transverse incision across the plantar surface. The tissues being dissected a little upwards from the bone, disarticulation is effected by forciby flexing the toe and cutting the extensor tendon transversely, and then severing the ligaments. The wound is closed so as to make an antero-posterior scar, protected from injury by the adjoining toes.

Fig. 182.



Amputation of toe by oval method.

In amputating the *great toe*, care must be taken to keep the incisions low, so as to provide ample covering for the head of the metatarsal bone which is apt to project in a troublesome manner; it is sometimes recommended that it should be cut off with strong forceps, but its removal is undesirable as it furnishes a very important point of support for the arch of the foot.

Amputation of all the Toes Simultaneously may be effected by the *plantar flap* method of Lisfranc, or by the somewhat more complicated procedure of Dubrueil. In the former, the surgeon applies the thumb and index finger of his left hand so as to mark the metatarso-phalangeal articulations of the fifth and great toes, and then with a narrow-bladed knife makes a curved incision, somewhat convex downwards, beginning (for the right foot) over the posterior part of the first phalanx of the fifth, and for the left foot over the corresponding part of the great toe. This flap being slightly dissected upwards, each toe is separately disarticulated, by dividing its extensor tendon and articular ligament, and the surgeon then, slipping the knife below the toes, which are raised for the purpose, cuts a plantar flap of sufficient size from within outwards. It is usually advised that the plantar flap should have been first marked out by a deep incision corresponding to the groove at the roots of the toes.

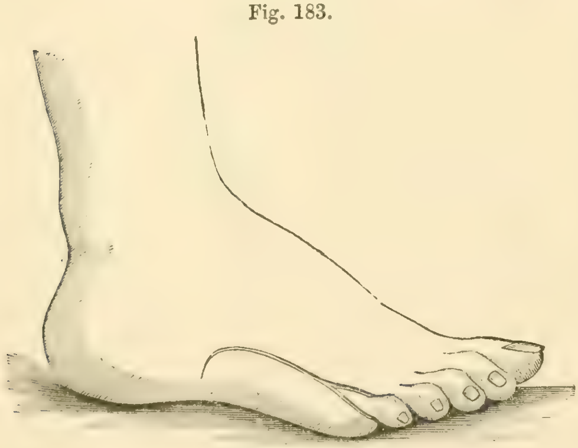
Dubrueil's operation resembles Lisfranc's as regards the mode of obtaining a covering for the metatarsal bones of the four smaller toes, but he supplements the plantar flap by taking an internal lateral flap from the side of the great toe, thus insuring an ample covering for its metatarsal.

For my own part, I would advise, as in the case of the fingers, that the surgeon should sacrifice brilliancy, and amputate each toe separately, by either the lateral flap or oval method as may seem best in each particular instance.

Amputations of the Foot.

Amputation of the Fifth Toe with part or all of its Metatarsal Bone is best effected by the *oval* (*en raquette*) *method*, the point of the oval being placed upon the dorsum of the foot, but, in order to give more room for separation of the bone, curved outwards as shown in Fig. 183. If part of the metatarsal only is to be removed, the bone may be divided with a narrow-bladed or chain saw, or with strong cutting pliers; if complete disarticulation is to be effected, the bone must be first separated from its attachment to the cuboid, and then from that to the fourth metatarsal, and in doing this the direction of the articulation (oblique, inwards and backwards) must be remembered. This amputation may also be done by the *external flap method*, but the operation is not to be commended, as the flap is long, narrow, and ill-nourished, and is apt to slough.

Fig. 183.

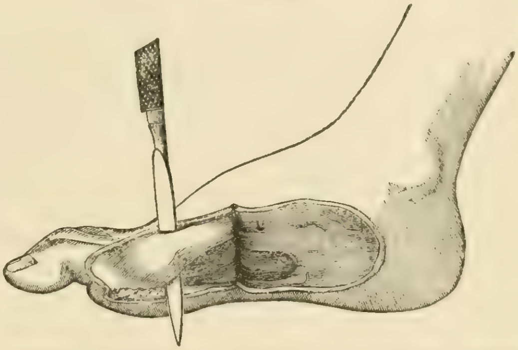


Amputation of fifth toe and metatarsal by oval method.

Amputation of the Great Toe, with part or all of its Metatarsal Bone, may also be performed by the *oval* (*en raquette*) *method*, the extremity of the oval being in this instance curved *inwards*, from the dorsum of the foot

to the edge of the sole, as advised by A. Guérin and Dubrueil. The *internal flap method* may also be advantageously practised in this situation (Fig. 184), a fleshy flap being first raised from the inner side of the foot, and replaced after disarticulation. The surgeon introduces a strong and rather short knife on the dorsal surface, on a level with the tarso-metatarsal joint and between the first and second metatarsal bones, and cuts directly forwards to the ball of the toe, then transversely outwards and downwards in a line corresponding to the web, and finally backwards along the inner side of the sole. The flap thus marked out is dissected upwards, keeping close to the bone, and the knife is then re-entered between the metatarsals and made to cut forwards through the web. Disarticulation is then effected by attacking the joint from its inner and dorsal sides, and by then dividing the interosseous ligament and the tendons of the peroneus longus and tibialis anticus, taking care not to wound the dorsal artery of the foot. This operation is readily performed, and affords a good stump, but upon the whole I am disposed to give the preference to the oval operation as making a smaller wound, and one of which the cicatrix is better placed as regards the future usefulness of the foot.

Fig. 184.



Amputation of great toe and metatarsal by internal flap method.

Amputation of two or more Metatarsal Bones is conveniently done by the *oval* (*en raquette*) *method*, the point of the oval being placed on the dorsum, and beginning about half an inch above the tarso-metatarsal joint, and its branches diverging sufficiently to include the toes which it is designed to remove. Béclard and Dubrueil advise that more room should be afforded for disarticulation by adding short transverse incisions on either side, at the upper end of the point of the oval. In all of these operations, it will be found advantageous to grasp the part to be removed with Fergusson's lion-jawed forceps, held firmly in the left hand, twisting the bone from side to side so as to render tense the parts which are to be divided.

I feel bound to say that the various operations on the foot, hitherto described, are not often applicable in actual practice: the injuries in civil life which require amputation of the metatarsal bones, usually involve the whole anterior portion of the foot; and the stumps which I have examined, resulting from these partial amputations after gunshot wounds, have not been as a rule very satisfactory.

Amputation through the Continuity of the Metatarsus.—This operation is not unfrequently required in cases of injury involving the base of the toes, or of gangrene following frost-bite. It may be done by either the *circular* or the *flap method*, the latter being, I think, preferable in this situation. Some operators employ a *single* dorsal flap, while others (as Pezerat, for instance) use *three* flaps—one from the dorsal, one from the plantar, and one from the inner side of the foot. I think that the best plan is to make a short dorsal and a long plantar flap, cutting both of them from without inwards, and, after sawing the bones on the same level, bringing up the plantar flap so as

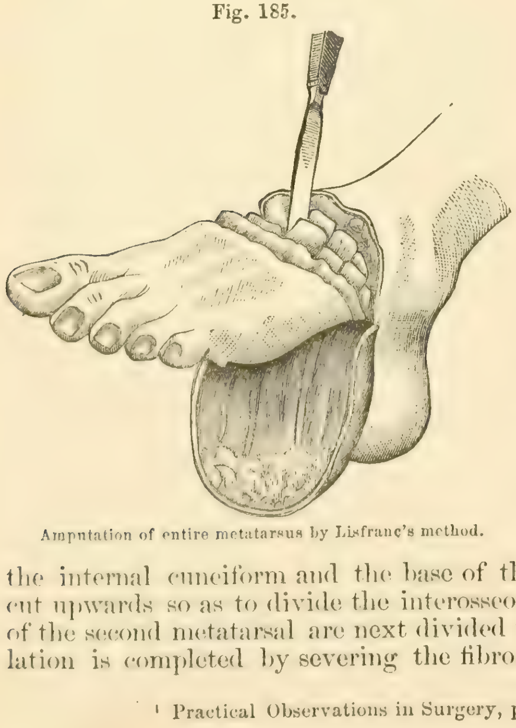
to get a cicatrix which shall not be exposed to pressure from the shoe in walking. This operation gives an excellent stump, and one which seems to be more serviceable than those obtained by amputation at a point nearer the ankle.

Amputation of the Entire Metatarsus.—This operation is said to have been formerly practised in a rude fashion by the North American Indians as a means of preventing their prisoners from escaping. It may be performed by either the *elliptical* or the *flap method*, the latter being that generally adopted. There are two principal varieties of this operation, known respectively by the names of Hey (of Leeds), and of Lisfranc.

(1) *Hey's amputation* is practised by cutting a long plantar flap from without inwards, the incision beginning on the outside at the tuberosity of the fifth metatarsal bone, passing downwards to the line of the metatarso-phalangeal articulations, then crossing the sole transversely in a curved line, and passing up again on the inner side of the foot to the prominence of the scaphoid bone. The upper ends of this wound are united by a curved incision, convex downwards, across the dorsum of the foot, making a short anterior flap. The four outer metatarsals are then disarticulated from the cuboid and external and middle cuneiform bones, and the projecting internal cuneiform cut across with a small saw. This operation has been modified by sawing across the base of the second metatarsal bone, instead of the internal cuneiform, but the latter was the part divided in the operation as originally performed in 1799 by Mr. Hey.[1] A similar operation is known to French surgeons by the name of Béclard, while Cloquet has carried the use of the saw still further, recommending its employment at any point at which disarticulation is found troublesome.

(2) *Lisfranc's amputation* differs from Hey's in being a pure disarticulation. (Fig. 185.) The surgeon begins his incision (for the right foot) at the tuberosity of the fifth metatarsal, carries it across the dorsum of the foot, in a curved line with its convexity downwards, and terminates it at the tubercle of the first metatarsal. This incision divides all the tissues down to the bone, and, the skin being retracted by an assistant, a few light touches of the knife serve to expose the line of the tarso-metatarsal joints. Disarticulation is then begun at the outer side, the fifth, fourth, and third metatarsals being first separated, and then the first; the second, which projects backwards behind the line of the others, being left until the others have been freed. The point of the knife is then entered between the internal cuneiform and the base of the second metatarsal, and made to cut upwards so as to divide the interosseous ligament; the dorsal ligaments of the second metatarsal are next divided transversely; and finally disarticulation is completed by severing the fibrous bands on the outer side of the

Fig. 185.



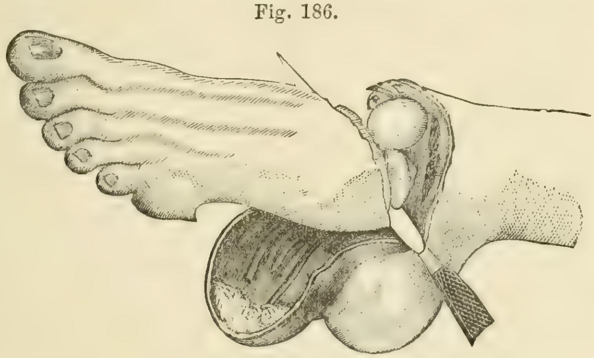
Amputation of entire metatarsus by Lisfranc's method.

[1] Practical Observations in Surgery, p. 331. Philadelphia, 1805.

same bone. The division of the interosseous ligament between the second metatarsal and internal cuneiform bones is the most difficult part of this manœuvre, and is best effected by thrusting the point of the knife firmly into the posterior part of the first interosseous space, and then forcibly elevating the handle—a motion which is described by French writers as the *tour de maître.* Disarticulation, which may be greatly aided by pressing the anterior part of the foot firmly downwards, having been completed, the knife is carried flatwise below the metatarsal bones, and made to cut a long plantar flap—rather larger on the inner than on the outer side—from within outwards. In order to secure greater regularity of the plantar flap, it is a good plan to mark out its dimensions with the point of the knife before proceeding to cut it; or the surgeon may adopt Duval's plan, and begin by cutting the flap from without inwards, as in Hey's operation.

Amputation at the Medio-tarsal Joint.—This operation (Fig. 186) bears the name of Chopart, although it is no longer performed in the way directed

Fig. 186.



Amputation at medio-tarsal joint.

by that surgeon.[1] Chopart made a square anterior flap from the dorsum of the foot, and, after disarticulating, cut the posterior or plantar flap from within outwards; but most surgeons, at the present day, adopt Richerand's and Lisfranc's modification, making a curved anterior flap of which the extremities reach to the position of the articulation, and many prefer to cut the plantar flap from without inwards, a plan which has the advantage of allowing the flap to be more regularly shaped than when it is cut in the opposite direction. The object of this operation is to remove all of the tarsus except the os calcis and the astragalus, but it has often happened that the scaphoid has been left unintentionally, without interfering at all with the successful result of the procedure, and, indeed, M. Laborie and Mr. Hancock advise that it should always be retained if possible, the latter surgeon sawing across the cuboid on a corresponding line.[2] In performing Chopart's amputation, the surgeon grasps the anterior part of the foot in his left hand, and with a strong, short knife makes a transverse incision, convex forwards, over the dorsum, from a point half-way between the external malleolus and the tuberosity of the fifth metatarsal on the outside, to a point about half an inch behind the prominence of the scaphoid, on the inner side of the foot. The plantar flap extends from the same points as far forward as the line of the metatarso-phalangeal joints. Disarticulation is rendered more easy by forci-

[1] A similar operation appears to have been known to Fabricius Hildanus.

[2] A similar operation is practised by Prof. Agnew, of Philadelphia, and by Dr. S. F. Forbes, of Toledo, Ohio.

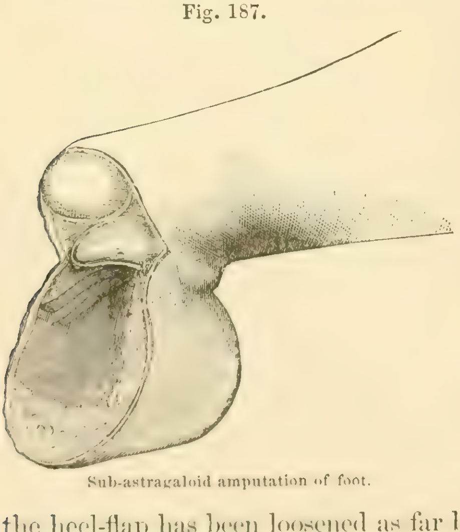
bly pressing the front of the foot downwards, so as to make the anterior ligaments as tense as possible.

Trouble is sometimes experienced during the after-treatment of patients who have submitted to Chopart's amputation, from contraction of the muscles of the calf drawing the heel upwards, thus, when the patient begins to walk, bringing the cicatrix against the sole of the shoe, and so causing irritation. This contraction can usually be prevented by bandaging the leg from above downwards, or by applying a broad strip of plaster connected with a weight and pulley, but division of the tendo Achillis may occasionally be required. Dubrueil recommends the use of a wedge-shaped pad in the shoe, the base of the wedge being directed forwards. Trouble from this source is less likely to be met with when the plantar flap is of ample dimensions, than when it is somewhat scanty.

The statistics of Chopart's amputation were particularly investigated by the late Mr. Hancock,[1] who found that 152 terminated cases gave but 11 deaths, a mortality of only 7.2 per cent., while no less than 120 of the 126 patients who recovered had useful limbs. Larger's figures,[2] from French sources, are less favorable, 38 cases having given 14 deaths, or 36.8 per cent., though only half of these were properly attributable to the operation.

Sub-astragaloid Amputation.—This operation appears to have been suggested by Lignerolles,[3] though it was, according to Hancock,[4] first performed by Textor in 1841. The peculiarity of the operation consists in the removal of the whole foot with the exception of the astragalus. Lignerolles and Velpeau advised that the surgeon should make two lateral flaps, and turn them upwards towards the malleoli before disarticulating. Lisfranc employed a single dorsal flap, and Malgaigne a single flap from the inner portion of the sole. Verneuil's method, which seems to be the one generally adopted in France, is somewhat differently described by different writers; it is essentially an application of the *oval method*, the point of the oval being placed on the outer side of the foot, below and behind the external malleolus, while the base of the oval crosses the inner side of the foot over the middle portion of the internal cuneiform bone. Nélaton modified this procedure by making another angle at the base of the oval, thus really making dorsal and plantar flaps, the junction of which was made further back upon the outer than upon the inner side. The plan recommended by modern English writers, and that which I have myself successfully followed in two cases (Fig. 187), is to make a flap from the heel, as in Syme's operation at the ankle-joint, only somewhat longer, with a short anterior flap from the dorsum. As soon as the heel-flap has been loosened as far back as the tubercles of the calcaneum, the anterior part of the foot may be cut away, and the os calcis then grasped

Fig. 187.



Sub-astragaloid amputation of foot.

[1] Operative Surgery of the Foot and Ankle-joint, p. 386. London, 1873.
[2] Bulletin de la Société de Chirurgie; *apud* Hayem, Revue des Sciences Médicales, Oct. 15, 1880.
[3] Velpeau, Traité de Médecine Opératoire, t. ii. p. 499. Paris, 1839. [4] Op. cit., p. 191.

with the lion-jawed forceps, and twisted from side to side, while its separation is completed by disarticulating it from the astragalus, and dividing the tendo Achillis and remaining attachments of the bone. If the flaps are not of ample dimensions, the head of the astragalus should be removed with a small saw, a step which Hancock recommends in all cases. This operation affords a most admirable stump, which has the advantage over those produced by Syme's and Pirogoff's methods that it retains the motions of the ankle-joint, and thus allows an elasticity of gait in walking, which would otherwise be absent. The appearance of the stump resulting from this operation is shown in Fig. 188, from a patient under my care, a year or two since, at the University Hospital.

Fig. 188.

Stump from sub-astragaloid amputation.

Mr. Hancock[1] refers to 22 cases of this operation (including one of his own), at least 20 of which terminated successfully. Larger[2] tabulates 21 cases, of which 5 proved fatal, only three of these, however, as the result of the operation. Both of my own cases resulted in recovery.

Hancock's Amputation.—This, which may be regarded as a combination of the sub-astragaloid with Pirogoff's method (to be presently described), consists in sawing through the os calcis as in that operation, and bringing the sawn surface in contact with a transverse section of the astragalus. This is certainly a very ingenious procedure, and in the case in which Mr. Hancock employed it, the result was all that could be wished. I confess, however, that it does not seem to me to present any advantage over the ordinary subastragaloid operation, which has the advantage of greater simplicity.

Tripier's Amputation.—This operation, which has been suggested by M. Tripier, of Lyons, may also be looked upon as a modification of the subastragaloid method. The external incisions are made as in Chopart's mediotarsal operation, and, the anterior part of the foot having been removed, the calcaneum is sawn through on a level with the *sustentaculum tali*, and on a plane at right angles to the axis of the leg.

Other Amputatons of the Foot.—Mr. Hancock's suggestion that, instead of amputating at the medio-tarsal joint, the scaphoid should be left with the posterior portion of the cuboid, has already been referred to. The same surgeon, reviving the teaching of Mayor, of Lausanne, advises that the foot should, for operative purposes, be looked upon as a whole, and that, after the formation of suitable flaps, the tarsus should be sawn through at whatever point may be found necessary, without regard to its articulations. Acting upon this suggestion, I, in one case, sawed through the scaphoid bone, the posterior part of which was healthy, and removed the anterior diseased sursurface of the os calcis; the patient made an excellent recovery.

The results of amputations of the toes and partial amputations of the foot are usually satisfactory. I have met with no fatal cases in my own experi-

[1] Op. cit., p. 205. [2] Loc. cit.

ence, and the records of British surgery and of the late American war show a very low rate of mortality; but the French statistics are much less favorable; the figures are shown in the following Table:—

TABLE SHOWING RESULTS OF AMPUTATIONS OF THE TOES AND PARTIAL AMPUTATIONS OF THE FOOT.

Authority.	Toes.			Partial of Foot.			Reference.
	Cases.	Deaths.	Mortality per cent.	Cases.	Deaths.	Mortality per cent.	
Otis	790	6	0.7	119	11	9.2	Circular No. 6, S. G. O., 1865, p. 45.
Hancock	...	..	....	174	13	7.4	Op. Surgery of Foot and Ankle-joint, pp. 205, 386.
Legouest	370	70	18.9	255	97	38.+	Chirurgie d'Armée, pp. 726, 731.
Larger	...	..	....	80	23	28.7	Revue des Sciences Médicales, Oct. 15, 1880.
Aggregates	1160	76	6.5	628	144	22.9	

AMPUTATION AT THE ANKLE.

Removal of the entire foot at the ankle-joint was somewhat vaguely referred to by Hippocrates, and subsequently by Fabricius Hildanus, and appears to have been occasionally resorted to by various surgeons, among whom may be particularly mentioned Sedilier, of Laval, Rossi, and Baudens; but the operation did not obtain general acceptance as a recognized procedure until the late Prof. Syme, of Edinburgh, introduced a new mode of performing it in the year 1842. Rossi had employed two lateral flaps, and Baudens a single dorsal flap, while Velpeau advised semi-lunar incisions over the heel and instep, the edges of the wound being brought together from before backwards, so that its angles should cover in the malleoli, which, in all of these methods, were allowed to remain. Various modifications of Syme's method have been suggested and practised, the most important being those of Roux, Pirogoff, Fergusson, and Le Fort.

SYME'S AMPUTATION.—As I quite agree with Mr. Hancock and Mr. Syme himself, that, in estimating the value of any particular operation, we should take care that the operation itself is performed in the manner directed by its introducer, and not confuse it with the modifications, or so-called "improvements," of other surgeons, I shall quote Mr. Syme's own description of his mode of procedure:—[1]

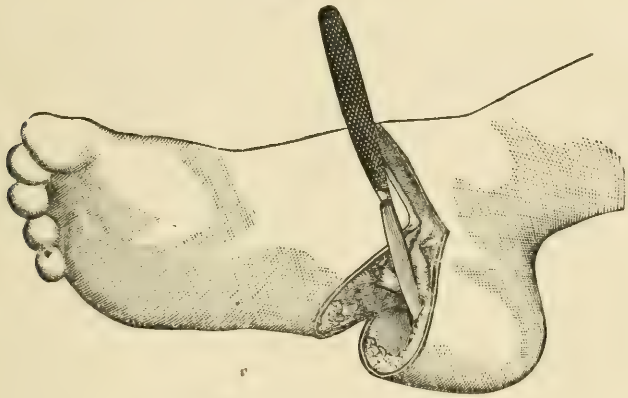
In performing the operation, the foot being held at a right angle to the leg, the point of a common straight bistoury should be introduced immediately below the fibula, at the centre of its malleolar projection, and then carried across the integuments of the sole in a straight line to the same level on the opposite side. The operator having next placed the fingers of his left hand upon the heel, and inserted the point of his thumb into the incision, pushes in the knife with its blade parallel to the bone, and cuts down to the osseous surface, at the same time pressing the flap backwards until the tuberosity is fairly turned, when, joining the two extremities of the first incision by a transverse one across the instep, he opens the joint, and carrying his knife downwards on each side of the astragalus, divides the lateral ligaments, so as to complete the disarticulation. Lastly the knife is drawn round the extremities of the tibia and fibula, so as to

[1] Observations on Clinical Surgery, p. 47. Edinburgh, 1861.

expose them sufficiently for being grasped in the hand and removed by the saw. After the vessels have been tied, and before the edges of the wound are stitched together, an opening should be made through the posterior part of the flap, where it is thinnest, to afford a dependent drain for the matter, as there must always be too much blood retained in the cavity to permit of union by the first intention. The dressings should be of the lightest description.

As already indicated, this operation (Fig. 189) has been modified or "improved" by various surgeons, some making the heel flap longer, and others shorter, than directed by Mr. Syme, and some only dissecting the flap back

Fig. 189.



Amputation at ankle by Syme's method.

to the point of the heel, and disarticulating before dividing the tendo Achillis and completing the separation of the os calcis. As regards the length of the flap, Dr. J. A. Wyeth, of New York, has proved by a large number of dissections that the main supply of blood to the heel flap is derived from the calcaneal branches of the external plantar artery, and that hence a long flap is less likely to slough than a short one: hence if any deviation is to be made from Mr. Syme's lines of incision, it should be in the direction of lengthening the flap rather than of abbreviating it. Provided, however, that the knife be kept close to the bone, in separating the flap from the calcaneum, there is not much risk of impairing its vitality. Syme's amputation affords an excellent stump, covered with the natural tissues of the heel, and capable of sustaining the entire weight of the patient. In some cases the tendo Achillis appears to acquire fresh attachments to the bones of the stump, and the patient is enabled not only to walk but to *run*. The same advantage is claimed for the stump made by Pirogoff's method, but the Syme stump is, according to Prof. Stephen Smith, of New York, better suited than the other for the adaptation of an artificial limb. A modification of Syme's method which seems to me to be really an improvement, is that employed by Macleod, of Glasgow, and J. Bell, of Edinburgh, which consists in preserving, whenever it is practicable to do so, the periosteal covering of the calcaneum.

The following Table shows the statistical results of Syme's amputation, as given by various authors:—

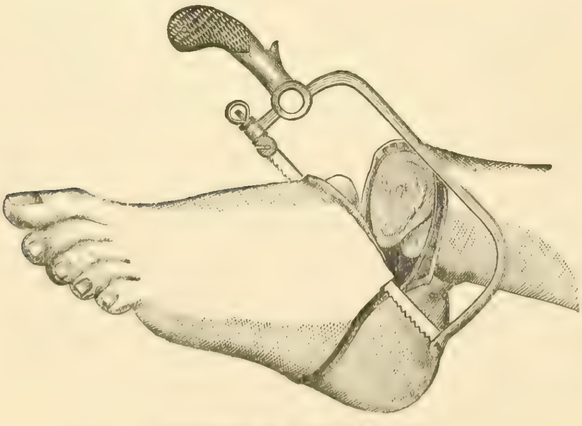
TABLE SHOWING THE RESULTS OF SYME'S AMPUTATION AT THE ANKLE.

Authority.	Cases.	Deaths.	Mortality per cent.	Reference.
Hancock . .	219	17	7.7	Operative Surgery of Foot and Ankle-joint, p. 152.
Spence . .	107	8	7.4	Lectures on Surgery, vol. ii.; Med. Times and Gaz., 1875 and 1876; Edin. Med. Journal, 1879.
Fayrer . .	12	8	66.6	Hancock, op. cit., p. 155.
Aggregates	338	33	9.7	

ROUX'S AMPUTATION.—In this operation, the flap is derived mainly from the inner side of the foot. The surgeon begins his incision at the posterior edge of the external face of the os calcis, carries it below the external malleolus, and then over the dorsum of the foot, in a curved line, convex forwards, half an inch below the articulation. This incision ends a little in front of the internal malleolus, and a second, starting from the termination of the first, crosses the sole somewhat obliquely backwards to the point whence the first took its origin. An irregularly oval wound is thus made with the point of the oval on the outer side of the foot. The malleoli are removed in this as in Syme's operation. I have no personal experience with this particular form of operation, but should not suppose that the stump would be as serviceable as that obtained by Syme's method.

PIROGOFF'S AMPUTATION.—The peculiarity of this operation consists in the removal of all the foot except the posterior part of the calcaneum, which is brought forward and placed in apposition with the sawn ends of the tibia and fibula, the articulating surfaces of the latter, with the malleoli, being removed as in the procedure of Syme and Roux. The operation is done as follows: The surgeon makes first a somewhat oblique incision, with an anterior convexity, across the plantar surface, from one malleolus to the other, coming a little further forward on the inner than on the outer side, so as to avoid the posterior tibial artery. The flap thus marked out is dissected backwards for about a quarter of an inch, and the extremities of the wound are then united by a second incision, also with anterior convexity, over the dorsal surface, and crossing the ankle in such a way as to expose the joint. This being opened, disarticulation is effected, and the surgeon then, slipping a narrow-bladed saw, or the blade of a "Butcher's" saw behind the astragalus (Fig. 190) saws through the os calcis, obliquely downwards in the line of the first incision. The ends of the tibia and fibula[1] are next removed, and, hemorrhage having been checked, the wound is closed with sutures. If Butcher's saw be used, the

Fig. 190.



Amputation by Pirogoff's method.

[1] It is somewhat uncertain whether Pirogoff himself removes more than the malleoli (see Hancock, op. cit., p. 161), but it is customary in England and in this country to remove the whole articulating surface.

leg bones may be divided from below upwards by reversing the blade of the instrument. Any tendency to tilting of the heel fragment by the action of the calf-muscles must be overcome in the manner directed in speaking of Chopart's amputation. Various modifications of this operation have been suggested, as that the tibia and fibula should be sawn before the calcaneum; that the latter should be sawn from below upwards, that it should be sawn obliquely, etc. Dr. J. S. Wight, of Brooklyn, saws through the os calcis, and then removes the foot and malleoli together, without disarticulation. But the most important modifications of Pirogoff's method are those of Sir W. Fergusson and Prof. Le Fort, which will be presently described.

Mr. Syme denounced the adoption of Pirogoff's method as "a certain sign of lax surgical principle," but other operators have entertained a more favorable view of the Russian surgeon's procedure. While I have myself preferred either the original method of Syme or the subastragaloid operation, I have seen most admirable stumps produced by Pirogoff's mode of amputating, and can entertain no doubt of its value. Its statistical results also are very favorable, as may be seen by the following figures: Pirogoff, in a letter to Mr. Hancock,[1] speaks of "nearly 100" cases in civil practice in Russia, and 60 during the Crimean war, and of the latter says, "I only know with certainty of seven deaths." O. Weber enumerates 40 cases, and estimates the mortality at 15 per cent. Fifteen cases reported by Kestnor, of Strasbourg, appear to have all terminated favorably. Eighty-one cases collected by Hancock, principally from British sources, gave only 7 deaths, a mortality of but 8.6 per cent., and 77 cases collected by Gross (of Nancy) and Pasquier gave only 8 deaths, a mortality of 10.3 per cent. Dr. A. Hewson and Dr. Forbes, of Philadelphia, have each performed the operation several times with excellent results.

Fergusson's Modification of Pirogoff's amputation consists in not interfering with the malleoli, unless they are themselves diseased, but thrusting the sawn end of the os calcis up between them. This plan has also been adopted by other surgeons, among whom I may mention Prof. Agnew, of Philadelphia, and Dr. Quimby, of New Jersey. In order to prevent retraction of the heel-flap, Sir William Fergusson also recommended division of the tendo Achillis as a preliminary step in the operation.

Le Fort's Modification of Pirogoff's operation is performed as follows: The external incisions are the same as in Roux's modification of Syme's amputation. The dorsal flap is loosened and raised so as to expose the ankle-joint, taking care, in working at the inner side, not to wound the posterior tibial artery. The ligaments which unite the foot to the fibula are then divided, with the ligaments between the calcaneum and the astragalus, allowing the luxation of the foot inwards. The anterior portion of the foot is next cut away at the medio-tarsal joint, and the astragalus seized with strong forceps to facilitate its enucleation. The os calcis is then depressed, and divided with a narrow-bladed saw from behind forwards, so as to remove all the upper part of the bone, beginning at the insertion of the tendo Achillis. The malleoli and articulating surface of the tibia are finally removed, and the sawn surfaces of bone placed in apposition. What is proposed to be accomplished by this particular form of operation, is to keep the os calcis in a comparatively normal position, and to permit the patient, in walking, to receive pressure on the thick tissue of the heel, which is accustomed to support it, rather than on the thin tissue behind the heel, which is apt to be drawn forwards when the operation is done by the original method of Pirogoff.

[1] Op. cit., p. 184.

The results of these various amputations at the ankle are quite satisfactory. The statistics of Syme's and Pirogoff's methods have already been referred to, but a more compendious view of the subject can be obtained from the following Table:—

TABLE SHOWING THE RESULTS OF AMPUTATIONS AT THE ANKLE.

Nature of operation.	s.	Deaths.	Mortality per cent.	Authority.
Syme's method .	338	33	9.7	Hancock, Spence, Fayrer.
Pirogoff's method	273	28	10.2	Pirogoff, Weber, Kestnor, Hancock, Gross, Pasquier.
Not specified .	358	101	28.2	Legouest, Otis, Larger.
Aggregates .	969	162	16.7	

AMPUTATION OF THE LEG.

Amputation of the leg may be performed at any part of the limb, the best operation being, I think, the circular or modified circular, in the lower third, and Sédillot's or Lee's flap method in the middle and upper portions. As a rule, the stump should be made as long as the circumstances of the case will permit, but we still are occasionally requested by patients to amputate at what used to be called the "point of election" (two or three inches below the tubercle of the tibia), so as to allow the use of a "peg" or "box leg," without the annoyance of the stump projecting backwards.

AMPUTATION IN THE LOWER THIRD OF THE LEG, or the supra-malleolar (*sus-malléolaire*) operation of French writers, is best performed by the *circular method*, the cuff of integument being slit upon its outer (fibular) side,[1] in order to obviate trouble in turning it up when the limb is a conical one; or by the *modified circular* method, in which case the skin flaps may be made either antero-posteriorly or transversely, according to the fancy of the operator. M. Guyon practises the *elliptical* method in this situation, taking the lower segment of the ellipse from the tissues covering the heel.

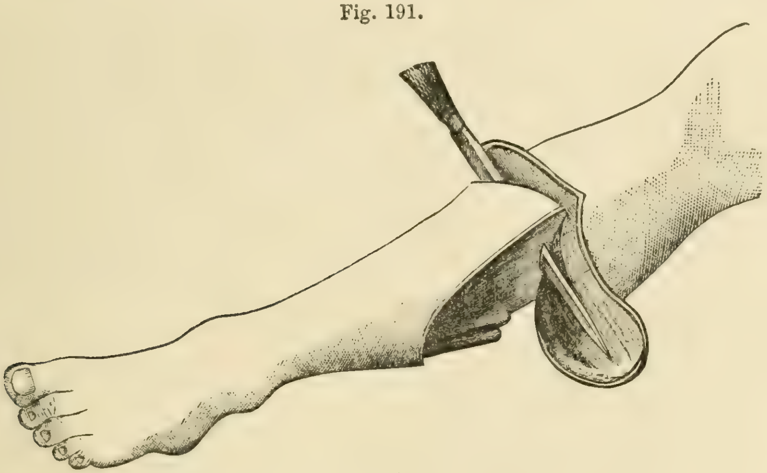
AMPUTATION IN THE MIDDLE OR UPPER THIRD OF THE LEG may be done by almost any of the operations which have been described, but the best, I think, are two varieties of the flap method, known respectively by the names of M. Sédillot and Mr. Henry Lee. Teale's method is less applicable in this situation than in the forearm, the long flap containing the anterior tibial artery, and being very thin where it overlies the tibia, and consequently liable to slough. The objections to the ordinary operation, in which a large flap is cut by transfixion from the calf, are that on the one hand, from its weight, it is apt to fall away from the anterior flap, and that on the other hand, the skin retracting more than the muscle, unless this is retrenched before the wound is closed, it is unduly compressed by the sutures which are employed, and great tension of the part, causing much discomfort, is almost sure to ensue.

External Flap Method, or that of Sédillot.—This is the operation which I prefer to all others for amputation in the upper part of the leg. It is performed as follows: the circulation having been controlled in the ordinary way, a preliminary longitudinal incision through the skin is made along the *inner*

[1] The operation known as Lenoir's is simply a circular amputation with the cuff slit in front instead of at the outer side, as I have advised.

edge of the tibia; the tissues being then drawn to the fibular side of the limb, the longitudinal incision gapes sufficiently to allow a slender catlin to be introduced close to the *outer* edge of the tibia, made to graze the fibula, and to be brought out posteriorly, transfixing the limb on the outer side of both bones. The knife is then carried downwards close to the bones, with a sawing motion, and then made to cut its way outwards, forming a broad, rounded flap. (Fig. 191.) The tissues on the inner side of the limb are next

Fig. 191.



Amputation of leg by external flap, or Sédillot's method.

divided by an incision somewhat convex anteriorly, and the bones then cleared by a circular sweep of the knife. The interosseous membrane being divided, all the tissues are pushed upwards with the hand or the handle of the knife, so as to expose the bone about an inch higher up before the application of the saw.

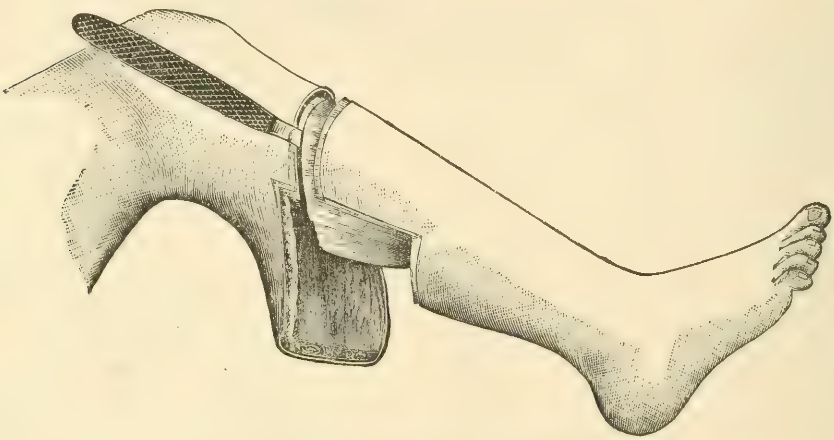
It is usually recommended that, in sawing the bones in any leg amputation, the instrument should be held vertically, and both bones cut through on the same level; but I am disposed to prefer the plan advised by Roux and Malgaigne, to wit, a separate division of the bones, and the removal of half an inch more from the fibula than from the tibia. Mr. Syme and other writers have directed that the sharp, anterior edge of the tibia should be removed by an oblique section either with saw or cutting pliers, to prevent its perforating the skin on the anterior face of the stump; but this precaution is hardly necessary if the flaps be sufficiently ample to prevent undue tension, while the oblique section of the bone rather increases, I think, the risk of necrosis and subsequent exfoliation. A better suggestion, in my judgment, is that of Ollier, of Lyons, who preserves a short flap of periosteum which is allowed to fall over the sawn end of the bone.

Besides the anterior and posterior tibial and peroneal arteries, there are usually two or three muscular and cutaneous branches which require ligation, and, in cases of secondary amputation, sometimes a great many more. Difficulty is sometimes met with in securing the anterior tibial artery, on account of its retracting above the point at which the interosseous membrane has been divided; under these circumstances the patient may be simply turned over on his face, when the weight of the stump will bring the knee into an extended position, thus straightening the vessel and making it more accessible. In applying the tourniquet for a leg amputation, the pad should be placed on either the femoral or the popliteal artery; if on the latter, a some-

what broad compress should be used, and the screw of the instrument should be applied diametrically opposite, upon the front of the limb, just above the patella.

Lee's Method.—This operation, which may be considered a modification of Teale's method, was described by Mr. Henry Lee, of St. George's Hospital, London, in a paper read before the Royal Medical and Chirurgical Society of that city in 1865.[1] The dimensions and shape of the flaps are the same as in Teale's method, but the longer is taken from the *back* of the leg, and embraces only the superficial muscles, the deeper muscles with the vessels being divided transversely by a circular incision on a level with the upper end of the flaps. The long flap made in this operation has less bulk and weight than that made by the ordinary transfixion method, but still seems to me, unless in very slender limbs, heavier than is desirable. I have, therefore, in muscular subjects, adopted a further modification, which consists in separating the gastrocnemius from the soleus muscle, and including the former only in the flap, the latter being divided circularly with the deeper layer. (Fig. 192.)

Fig. 192.



Amputation of leg by Lee's method (modified).

Amputation above the Point of Election may be done by the *circular*, or Larrey's method, the fibula being separated by disarticulation, and the tibia sawn through immediately below the attachment of the ligamentum patellæ.

The risks of amputation of the leg are not inconsiderable, the death-rate, for all cases taken together, being, as shown by the Table on page 630, no less than 34.3 per cent., or more than one in three. The danger increases with the proximity of the seat of operation to the trunk, the mortality of the supra-malleolar amputation being less than that of amputation at the point of election. At least, this has been my own impression, and it is confirmed by the statistics published by Dr. Gorman from the records of the Boston City Hospital,[2] which give the death-rates of amputations in the upper, middle, and lower thirds of the leg, as being respectively 42.8 per cent., 26.9 per cent., and 22.2 per cent. The late Dr. Otis,[3] too, reported of the supra-malleolar operation, that during the late American war its mor-

[1] Medico-Chirurgical Transactions, vol. xlviii. p. 195.
[2] Medical and Surgical Reports of the Boston City Hospital, Second series. Boston, 1877.
[3] Circular No. vi., S. G. O., 1865, p. 47.

tality-rate was "surprisingly small." A different view has, however, been taken by other writers: thus Larger[1] gives the figures of the supra-malleolar operation as 122 cases with 59 deaths, a mortality of no less than 48.3 per cent., while Legouest[2] reports that in the French army, in the Crimean war, 47 cases gave 26 deaths, a mortality of 55.4 per cent., or somewhat larger than that of all leg amputations taken together.

Amputations at the Knee and Knee-joint.

By amputation *at the knee-joint* is meant a pure disarticulation; in amputation *at the knee*, a larger or smaller portion of the femoral condyles is also removed, and in this category are included the various special forms of operation which are known as Carden's and Gritti's, and the "supra-condyloid amputation" of Dr. Stokes.

Amputation at the Knee-joint.—This operation, though briefly referred to by the older writers, and resorted to in isolated instances by Petit, Hoin, Brasdor, Richerand, Nathan Smith, of New Haven, and other surgeons, has only been accepted as a recognized mode of procedure for a little over fifty years, having been advocated and introduced into modern practice by Velpeau, whose first operation appears to have been performed in January, 1830. Disarticulation at the knee-joint may be done by either the circular or the elliptical method, or by making anterior, posterior, or lateral flaps. The *circular method* presents no special advantage in this locality, and it is difficult of performance on account of the irregular shape of the part. The best operations in this situation are, I think, the elliptical and the anterior flap methods.

Elliptical Method.—In this operation, which is known as Baudens's, the surgeon begins his incision over the posterior part of the inner tuberosity of the tibia, about an inch and a half below the line of the articulation; cutting at first longitudinally downwards, the knife is then made to cross the front of the limb with a curved incision, *concave* upwards, and reaching two and a half or three inches below the tibial tubercle, thence passing upwards on the outer side to a point half an inch below and behind the head of the fibula, and finally across the back of the limb in a *slightly* curved incision, *convex* upwards, to the place of commencement. In the last part of the incision, the superficial muscles should be divided as well as the skin. The large anterior flap thus marked out is now dissected upwards, keeping the edge of the knife close to the bone, until the ligamentum patellæ is exposed; this is next divided transversely, and disarticulation then effected by cutting the lateral and crucial ligaments—the knee being forcibly flexed for the purpose—when finally the knife is slipped behind the joint, and the tissues of the ham cut through from within outwards by a single stroke. The popliteal is the only large artery divided, though several small branches usually require ligation also. The wound is brought together from before backwards, so as to furnish a semicircular cicatrix which shall be well protected behind the condyles of the femur.

Anatomically, this operation should afford a better stump than any other method, but it is almost invariably found in practice that the retraction at the back of the wound is so great as to render its closure very difficult, and to cause so much tension upon the sutures as to endanger the vitality of the tissues. The anterior flap method preserves all its good features, and, by

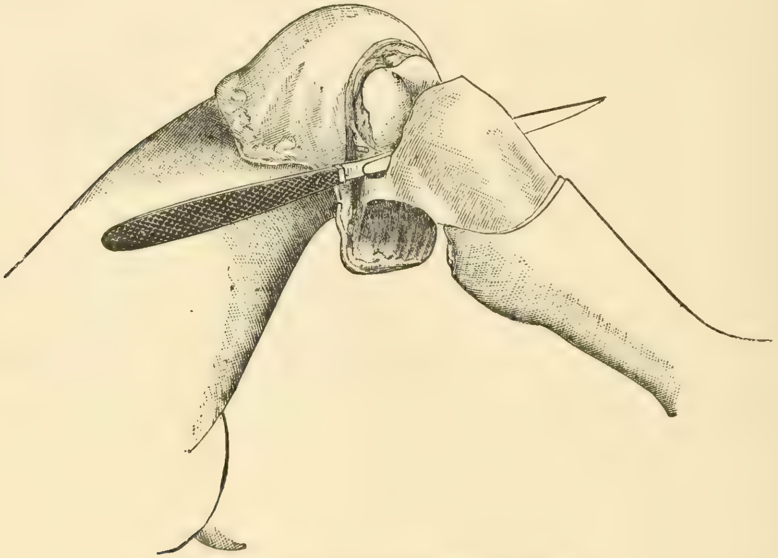
[1] Bulletin de la Société de Chirurgie, *apud* Revue des Sciences Médicales, Oct. 15, 1880.
[2] Traité de Chirurgie d'Armée, p. 734. Paris, 1863.

superadding a square flap from the back of the limb, obviates its disadvantages.

Posterior Flap Method.—This, which is known as Hoin's method, I do not hesitate to pronounce to be a bad operation. The large muscular flap, taken from the calf, is so heavy as to be with difficulty kept in position, and the resulting cicatrix is placed in the least desirable position.

Anterior Flap Method.—This, which is essentially the method adopted by Nathan Smith, of New Haven, in 1824, is, I think, upon the whole, the best mode of removing the limb at the knee-joint. The anterior flap, which is almost entirely a cutaneous one, is made very much as the anterior branch of the ellipse in Baudens's operation, except that it is rather more square (Fig. 193); a shorter, square, posterior flap is also cut from the integument of the

Fig. 193.



Amputation at knee-joint by anterior flap method.

upper part of the calf, and, after disarticulation, the wound is brought together, making a small cicatrix which is well protected from pressure.

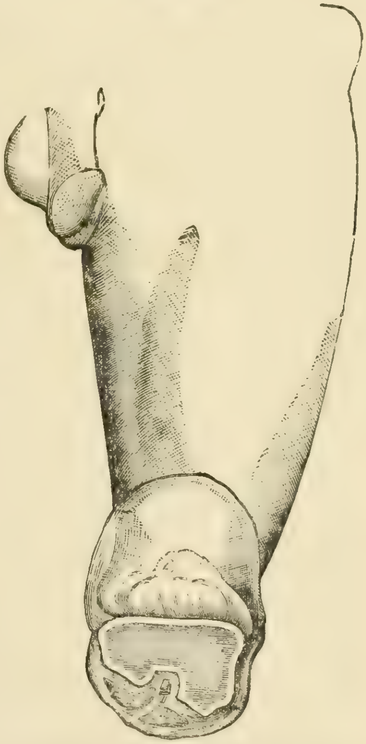
Lateral Flap Method.—This mode of performing the operation was introduced by Rossi, and consists, as its name implies, in taking flaps from either side of the leg, the resulting cicatrix being placed midway between the two femoral condyles. This operation has been improved by Prof. Stephen Smith, of New York, by carrying the point at which the flaps join posteriorly further up than in front. A convenient means of effecting drainage is thus provided, while the natural coverings of the front of the knee are not interfered with. A similar operation is employed by Prof. Smith in amputating both above and below the knee.

Some difference of opinion exists as to whether or no the patella should be removed in amputating at the knee-joint, but I strongly recommend that it should be retained. Its presence adds greatly to the rotundity and firmness of the stump, and its removal renders the anterior flap so thin that sloughing

may follow. Mr. Erichsen advises that, in order to prevent retraction, the flap should be turned upward and the attachment of the quadriceps femoris divided, but in my own cases I have not found this necessary. The semilunar cartilages should, I think, be removed, though A. Guérin recommends their retention. The articular cartilage of the femur need not be interfered with: it undergoes spontaneous separation, by a process of slow exfoliation, and comes away with the discharge in shreds or fragments of greater or less size during the second or third week; some writers advise that it should be removed by sawing around the condyles with a Butcher's saw, but this seems to me an unnecessary complication.

Amputation at the Knee.—Amputation at the *knee*, as distinguished from the *knee-joint*, may be done by any of the methods above described, the only difference between this operation and the disarticulation being that a portion more or less considerable of the end of the femur is removed by sawing through the condyles. The *anterior flap method* gives, I think, the best result, and, the patella being retained, furnishes an admirably firm and rounded stump. Several special forms of operation are practised in this situation, and may be here briefly referred to.

Fig. 194.



Amputation at knee by Carden's method.

Carden's Amputation.—This operation, which was introduced by Mr. Carden, of Worcester, is done by taking a large rounded skin flap from the front of the knee; dividing the tissues on the back of the limb by a single transverse incision, made either by transfixion or from without inwards, on a level with the base of the flap; reflecting the flap and dividing the deeper tissues straight down to the bone, above the patella which is drawn downwards by flexing the knee; and finally sawing through the base of the condyles. (Fig. 194.) This method of operating is undoubtedly better than Syme's plan (which that surgeon abandoned in favor of Carden's) of taking a posterior flap to cover the sawn end of the condyles, but seems to me less desirable than that which I have described simply as amputation at the knee—a posterior being added to the anterior flap, and the patella being preserved. It has, however, been very successful in the hands of its author, thirty cases recorded by Mr. Carden himself having given but five deaths and twenty-five recoveries.[1]

Gritti's Amputation.—This operation, introduced by Rocco Gritti, of Milan, in 1857,[2] may be regarded as an application of the osteo-plastic method of Pirogoff, to amputations at the knee. A rectangular flap is taken from the front of the leg and knee, and a shorter flap from the back of the limb; the

[1] British Medical Journal, 1864. Mr. Carden reports thirty-one cases, one of which, however, appears to have been a disarticulation.
[2] Annali Universali di Medicina. Milano, 1857.

lower surface of the patella is removed with a small saw,[1] and the condyles similarly divided through their base, the two sawn surfaces being then brought into apposition. A very good stump results from this rather complicated procedure.

Stokes's Modification of Gritti's Amputation is called by its author, Dr. W. Stokes,[2] of Dublin, a *supra-condyloid amputation of the thigh*, whereas the line of section in Gritti's method is *trans-condyloid*. This operation differs from that of the Italian surgeon simply in the fact that the anterior flap is oval instead of being rectangular; that the posterior flap is made somewhat larger (one third the length of the anterior); and that the femur is sawn through half an inch above the condyles, instead of through their base. The freshly sawn surfaces of the femur and patella are brought together as in the Italian operation, and fixed by means of a catgut suture passed through the soft tissues immediately behind the bone, and with both ends cut short and left in the wound.

The merits of these various forms of operation have been investigated by numerous surgeons, among whom I may particularly mention Profs. Stephen Smith[3] and Markoe,[4] and Dr. R. F. Weir,[5] of New York; Dr. J. H. Brinton,[6] of Philadelphia; Mr. Pollock,[7] of London; and Dr. Salzmann,[8] of Potsdam, who has particularly studied Gritti's method in regard to its applicability in military practice. Dr. Brinton, including in his Tables Prof. Markoe's and Dr. Otis's cases, refers in all to 494 examples of these different operations, death having followed in 207; Dr. Weir tabulates 76 cases (of Gritti's and Stokes's operations) with 22 deaths; Mr. Pollock 48 cases of various kinds with 13 deaths; while Dr. Salzmann collects, in all, 396 cases with 231 deaths. In the following Table I have included only terminated cases, and have taken care to avoid duplication in combining the statistics of the various authors quoted.

TABLE SHOWING THE RESULTS OF AMPUTATIONS AT THE KNEE AND KNEE-JOINT.

Authority.	Cases.	Deaths.	Mortality per cent.	Reference.
Brinton (various sources)	233	76	32.6	Amer. Journ. of the Med. Sciences, April, 1868.
Otis (American war)	202	106	52.4	Ibid. (Quoted by Brinton.)
Carden (knee-amputation)	30	5	16.6	British Med. Journal, April 16, 1864.
Bryant (individual experience)	23	5	21.7	Manual for the Practice of Surgery, Third edition.
Pollock (various sources)	42	13	30.9	Med.-Chir. Transactions, vol. liii.
Legouest (Crimean war)	85	75	88.2	Traité de Chirurgie d'Armée, 1863.
Salzmann, knee-amputations (various sources)	138	67	48.5	Archiv für klin. Chirurgie, Bd. xxv. H. 3.
Id., knee-joint amputations (Mexican, Italian, Austrian, and Franco-German wars)	41	32	78.+	Ibid.
Aggregates	794	379	47.7	

[1] Mr. Pollock employs cutting forceps for this purpose.
[2] Medico-Chirurgical Transactions, vol. liii. p. 175. London, 1870.
[3] New York Journal of Medicine, November, 1852.
[4] New York Medical Journal, March, 1868.
[5] New York Medical Record, April 12, 1879.
[6] American Journal of the Medical Sciences, April, 1868.
[7] Medico-Chirurgical Transactions, vol. liii. 1870.
[8] Archiv für klinische Chirurgie, Bd. xxv. H. 3, 1880.

The general death-rate, then, of these amputations at the knee-joint and knee, appears to be 47.7 per cent., or not quite one in two. Comparing this with the mortality of leg and with that of thigh amputations, as given in the Table on page 630, we find it almost midway between them, thus sustaining the general rule that the gravity of amputation increases as the operation is done nearer the trunk.

	Cases.	Deaths.	Mortality per cent.
Amputation of the leg	5247	1804	34.3
" " knee	794	379	47.7
" " thigh	5606	3527	63.8

It is difficult to estimate the comparative mortality of the special forms of amputation which have been referred to, as authors do not distinguish clearly between them; thus Dr. Brinton includes cases of Gritti's operation with ordinary amputations at the knee; Dr. Otis groups together all amputations whether of the knee or knee-joint; and Dr. Salzmann embraces in his Table of Gritti's operations, many cases in which the condyles were not touched. As a practical rule for treatment, I would advise that when there is ample tissue for the formation of flaps, and the joint itself is not involved, simple disarticulation should be preferred; but that under other circumstances the condyles should be removed. The patella is, I think, best retained under all circumstances; if it is itself diseased, however, its articulating surface should be excised either with saw or cutting forceps.

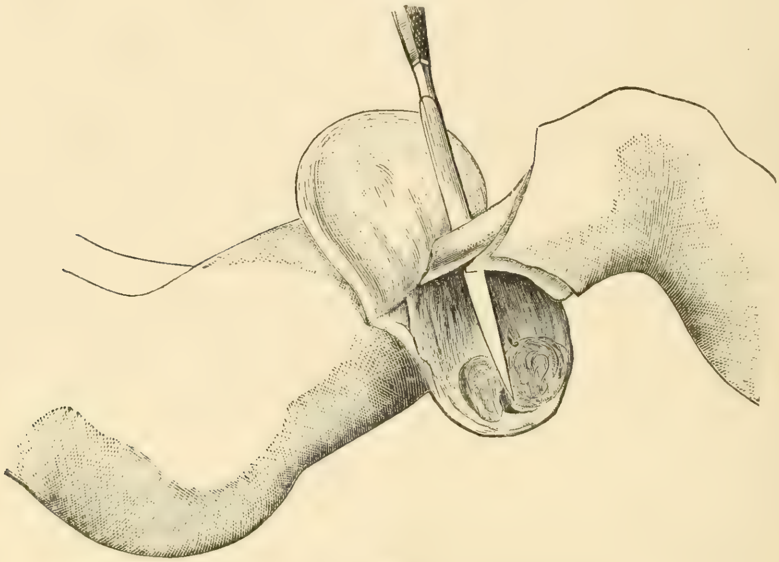
Amputation of the Thigh.

The thigh may be amputated by almost any of the methods which are employed in other parts of the body, but those which I am in the habit of employing, and to which I give the preference, are the *antero-posterior flap operation*, for amputations in the lower third of the thigh, and for those in the middle and upper thirds, the *modified circular*.

Amputation in the Lower Third of the Thigh.—This operation is often required in cases of injury involving the knee-joint, such as compound fractures and dislocations, and in cases of disease of that articulation, in which the femur is too extensively implicated to permit of amputation through the condyles. The double flap method is the best in this situation, and I much prefer to take the flaps from the front and back of the thigh (Fig. 195), rather than from its sides, because the femur being placed very near the front of the limb, its sawn end is apt to protrude through the wound when the operation by lateral flaps is adopted. In amputating by *antero-posterior flaps*, the surgeon introduces his knife on the side of the thigh, an inch or an inch and a half below the point at which he intends to divide the bone, and carries the blade longitudinally downwards for a space fully equal to half the diameter of the part, then crossing in front of the limb with a curved incision, convex downwards, and finally ascending to a point on the other side of the limb, opposite to that at which the incision was begun. There is thus marked out a rather square flap, with rounded corners, reaching usually to the upper border of the patella. This flap is dissected up with rapid strokes of the knife, including all the tissues down to the bone, and is then intrusted to an assistant, while the operator forms the posterior flap by transfixing the limb behind the femur, and cutting first downwards, with a sawing motion, and then almost directly backwards. The posterior flap should be made nearly as long as the anterior, the greater retraction of the muscles at the back of the

thigh rendering it important that the lower flap should be of ample size. If the knife be kept close to the bone, in cutting the posterior flap, this, if the limb be a large one, will be found to be thick and unwieldy; hence in operating upon muscular subjects, it is better to follow Sédillot's plan, and, by keeping the knife away from the bone, include in the flap only the superficial

Fig. 195.



Amputation of thigh by antero-posterior flap method.

muscles; or the flap may be made of the proper dimensions by cutting it from without inwards. Both flaps having been formed, the bone is cleared by a circular sweep of the knife, and the tissues are then pushed upwards, so as to allow the application of the saw an inch or more above the point of junction. At least seven or eight ligatures will be required after amputation in the lower third of the thigh, and sometimes a much larger number. An admirable stump is afforded by this mode of operating, the bone being well covered by the anterior flap, and the cicatrix drawn out of the line of pressure. In applying the tourniquet for amputations in the lower part of the thigh, the compress should be placed over the femoral artery at the apex of Scarpa's triangle.

Amputation in the Middle or Upper Third of the Thigh.—In either of these situations, the best operation is, I think, the *modified circular*. The skin flaps should be taken from the front and back of the limb (see Fig. 147, page 583), and care should be taken, after dividing the muscles, to push them well upwards, so that the bone may be sawn at a considerably higher point. The muscles on the back of the limb should be cut rather longer than those in front, on account of their greater tendency to retraction. In amputating at the upper part of the thigh, there may not be room for the application of the tourniquet, and the surgeon must then use an aortic compressor of some kind (as in amputating at the hip), or must rely upon manual pressure by an assistant. The best mode of controlling the circulation by manual compression, is, standing beside and behind the patient, to grasp the great trochanter of the limb to be removed with the fingers of the corresponding hand, and with the thumb make firm pressure on the artery just below Poupart's ligament; the

thumb of the other hand is at the same time superimposed to regulate and aid the compression, and to prevent any danger of slipping.

Amputation through the Trochanters.—This operation, which is only less grave than amputation at the hip-joint, may be required in cases of injury, or in those of tumor involving the lower part of the femur. When practicable, it should be preferred to disarticulation, even in cases of malignant growth, as being a less dangerous operation in itself, and as no more likely to be followed by recurrence of the disease, which, when it does return, is at least as apt to attack the pelvis as the stump itself. Should it be found, moreover, after sawing through the trochanters, that the disease has extended higher up, it is very easy to convert the operation into a disarticulation by simply dissecting out the head and neck of the femur. The *modified circular operation* is well adapted for amputations in this situation.

The above are the modes of operating to which I would advise a resort in cases of thigh amputation, in which the surgeon has the opportunity of selecting his method. It may well happen, however, that the structures on one side of the limb may be hopelessly diseased or injured, while those on the opposite side may be comparatively healthy; under such circumstances the surgeon must try to utilize the sound parts wherever they are situated, and must secure a covering for the stump from whatever part is most available for the purpose. Single flaps, double flaps, triple flaps—any device may be resorted to—it being much more important in any given case to remove the limb at as low a point as possible, than to follow the details of any particular plan of procedure. *Teale's method* affords a beautiful and useful stump in thigh amputations, but, for reasons already given (page 588), it seems to me an undesirable operation in this particular locality.

The death-rate of thigh amputations, taken all together, appears from the Table on page 630 to be 63.8 per cent., or more than five in eight. From the figures on the same page, it is seen that, in military practice, the mortality has varied from about one in two, for amputations in the lower third of the thigh, to the enormous proportion of seven in eight, for amputations in the upper part of the limb.

Amputation at the Hip-joint.

The removal of the lower limb at the coxo-femoral articulation may be properly regarded as the gravest operation which the surgeon is ever called upon to perform,[1] and it is only within a comparatively recent period that it has been accepted as a justifiable procedure. Ravaton wished to perform the operation in 1743, but the other surgeons called in consultation forbade the attempt.[2] The case usually referred to as the first amputation at the hip, occurred five years later (1748),[3] in the person of a lad of 13 or 14, who had been attacked with gangrene of both lower extremities as the result of eating spurred or smutty rye (*blé ergoté*). On the right side a line of separation had formed at the hip, and when the limb was almost completely detached

[1] "Obliged, as we are," says Hennen (Principles of Military Surgery, page 40. Third edition. London, 1829), "coolly to form our calculations in human blood, there is still something in the idea of removing the quarter of a man, at which the boldest mind naturally recoils." "There is not one patient in a thousand that would not prefer instant death to the attempt."

[2] Velpeau, op. cit., t. ii. p. 538.

[3] Barbet, Prix de l'Académie Royale de Chirurgie, t. iv. p. 47. Paris, 1819.

by the efforts of nature, M. Lacroix, the attending surgeon, removed it by simply dividing with scissors the ligamentum teres and the sciatic nerve. Four days afterwards, the left limb was painlessly and bloodlessly amputated on a level with the great trochanter, by sawing through the bone which was exposed by the separation of the gangrenous soft parts. The patient did well for a while, but finally succumbed, eleven days after the second, and fifteen days after the first operation. A quarter of a century later (1773 or 1774), Perault, a surgeon of Sainte-Maure, performed a similar operation upon a man named François Gois, whose thigh had been crushed between the pole of a carriage and a wall, and had subsequently become gangrenous. The limb was almost entirely separated by the processes of nature, and Perault merely completed its removal. The patient recovered, and twenty years afterwards was working as a cook in an inn of Sainte-Maure, was married, and had a healthy child.[1]

The first amputation at the hip, *through living parts*, appears to have been performed by Mr. Henry Thomson, Surgeon to the London Hospital, some time before 1777—that is, if his namesake, Dr. John Thomson,[2] is correct in supposing that it was this case the "horridness" of which provoked Mr. Percival Pott's denunciation of the procedure, in his Remarks on Amputation, written in that year.[3] In December, 1778, Mr. Kerr, of Northampton, amputated at the hip in the case of a girl of eleven years, who was suffering from advanced hip-disease and phthisis, and who survived the operation eighteen days.[4] The first hip-joint amputation in military practice occurred in 1793, the patient being a French soldier of the Army of the Rhine, and the operator, the illustrious Baron Larrey.[5] The case terminated unfavorably owing to the patient's being obliged to accompany the troops in a forced march, which they were compelled to undertake a few hours after the operation. Three cases (two successful) are attributed to the elder Blandin (Larrey's assistant), in 1794, but, though Velpeau and Lisfranc both refer to them, they give no reference to their authority, and certain contemporary or nearly contemporary writers, including Larrey and the younger Blandin,[6] do not mention their occurrence, so that their authenticity has been called in question. Brownrigg (in 1811) was the first British army surgeon to attempt the operation, which he repeated successfully in the following year, the latter case being, if Blandin's claims are disregarded, the first instance of recovery from the operation known to military surgery.

Amputation at the hip-joint may be performed in many ways—Farabeuf speaks of over forty-five methods—and writers on Operative Surgery describe more than one mode of procedure recommended by surgeons who, whatever their skill in operating upon the dead body, have never had occasion to amputate at the hip of a living person. I shall enumerate only the more important methods.

Oval Method.—On a slender limb, this operation, which is known by the name of Cornuau and Scoutetten, gives a well-formed and serviceable stump, particularly if Malgaigne's modification (*en raquette*) be adopted. The surgeon first makes a longitudinal incision of about three inches on the outer side of

[1] Sabatier, quoted by Velpeau, op. cit., t. ii. p. 539, and by Lisfranc, op. cit., t. ii. p. 381.

[2] Report of Observations made in the British Military Hospitals in Belgium, etc., p. 264. Edinburgh, 1816.

[3] Chirurgical Works of Percival Pott, vol. iii. p. 218, and Life, by Sir James Earle, Ibid., vol. i. p. xxv. London, 1808.

[4] Medical and Philosophical Commentaries. By a Society in Edinburgh, vol. vi. Part iii. page 337. London, 1779.

[5] Mémoires de Chirurgie Militaire et Campagnes, t. ii. p. 180. Paris, 1812.

[6] Dictionnaire de Médecine et de Chirurgie Pratiques, t. ii. p. 280. Paris, 1829.

the limb, over the trochanter major, and then diverges in front and behind, carrying the lateral branches of the oval obliquely downwards and inwards, until they meet transversely on the inner side of the thigh. The first incisions divide the skin and fascia, and the next step is the severance of the muscles (except in the region of the main vessels), at the same level or a little higher. The joint is opened from the outer side, and, after disarticulation, the remaining tissues are cut through from within outwards as in Larrey's similar operation at the shoulder. However appropriate this operation may be in the case of a patient emaciated by disease, it is evident that, in a robust limb, the adductor muscles would form a bulky and cumbrous mass, which would interfere with the satisfactory adjustment of the wound, and would probably prevent primary union.

Modified Circular Method.—This mode of operating is particularly indicated when amputation is required on account of a tumor which encroaches upon the upper part of the limb. Short antero-posterior skin flaps are cut from without inwards, and the muscles then divided by a circular incision at the level of the joint. This form of operation is convenient when the surgeon is not satisfied that the circulation is thoroughly controlled by pressure, as it exposes the femoral artery and vein, and affords an opportunity for securing them with ligatures before they are divided. The modified circular method has been rather a favorite with American surgeons, in this situation, and I may particularly mention, among those who have adopted it, the late Dr. J. Mason Warren, of Boston, and my colleague, Prof. Agnew, of Philadelphia.

Single Flap Method.—This operation, which seems to be the favorite with most French surgeons, is performed by taking a large flap from the anterior or antero-internal surface of the limb, and dividing the remaining tissues by a circular incision, either before or after disarticulating. The flap is usually made by transfixion, the operation then being known by the name of Manec. A long, double-edged knife is entered flatwise, midway between the anterior superior spinous process of the ilium and the great trochanter (the limb being slightly flexed so as to relax the muscles on its anterior surface), and directed at first inwards and a little upwards, so as to graze the head of the femur and open the capsule of the joint. The handle of the knife is then raised so as to depress its point, and transfixion is next effected by pushing the instrument steadily onwards until it emerges at the middle of the line which separates the thigh from the scrotum. The flap is then formed by cutting downwards with a sawing movement, keeping the knife close to the bone, and taking care to make the inner part of the flap as long as the outer: the flap is terminated at the middle of the thigh. An assistant slips his fingers beneath the flap, and grasps the femoral artery before it is divided. The surgeon then opens the joint from the front, cuts the muscles on either side, the ligamentum teres, and the muscles attached to the great trochanter, and finally completes the separation of the limb by making a transverse incision through the posterior tissues, from without inwards. Lenoir modified Manec's procedure by dividing the tissues on the back of the limb before disarticulating.

Other modes of performing the single flap operation are that of Lalouette, who began with a transverse, external incision, then disarticulated, and cut an internal flap as the last stage of his procedure; that of Plantade and Ashmead (of Philadelphia), who made an anterior flap by cutting from without inwards; and that of Delpech, who first tied the femoral artery below Poupart's ligament, then cut an internal flap by transfixion, and finally severed the external tissues, thus reversing the steps of Lalouette's method.

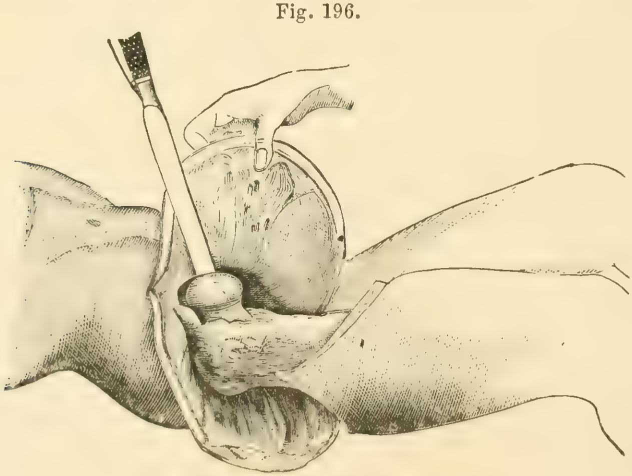
The single flap operation may be suitably resorted to when the destruction of the soft parts, by injury or disease, has extended much further on one side of the limb than on the other; and it may even be proper, under such circumstances, to employ a posterior flap; but when the surgeon can choose his operation, he will, I think, do better to adopt either the oval or modified circular, or the double-flap method after the manner of Guthrie, which will be presently referred to.

ANTERO-POSTERIOR FLAP METHOD.—We may recognize three varieties of this operation, which I shall designate respectively by the names of Liston, Béclard, and Guthrie.

Liston's Method.—This form of the operation is very generally adopted in England and in this country, and is, perhaps, the best of the transfixion methods. The point of a long knife is introduced between the great trochanter and the anterior superior spinous process of the ilium; made to graze the anterior surface of the neck of the femur; and, finally, brought out just in front of the tuber ischii, very much as in Manec's procedure. An antero-internal flap, about five inches in length, is then cut from within outwards, and, after disarticulation, a corresponding flap is cut from the buttock and tissues on the back of the thigh.

Béclard's Method.—In this procedure the posterior flap is cut first. The point of the knife is introduced a little above the trochanter; pushed across the limb, grazing the *back* of the femoral neck; and made to emerge at the innermost part of the gluteal crease. A flap is then cut from the tissues of

Fig. 196.



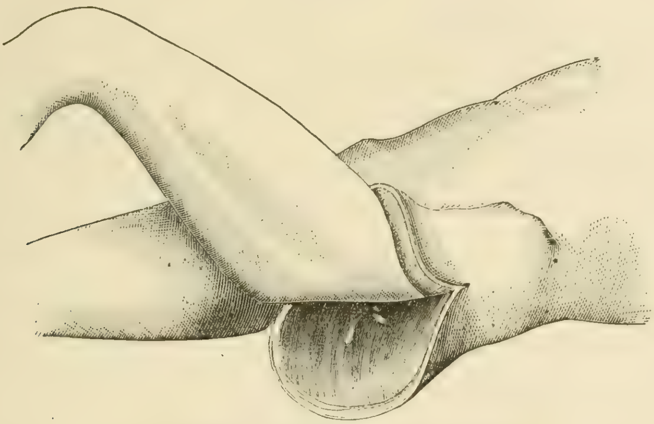
Amputation at hip-joint by Béclard's method.

the buttock, and the knife, being re-introduced at the same point as before, is made to traverse the limb, this time in front of the joint, and to cut the anterior flap from the front of the thigh. Disarticulation is in this method the last step of the operation. (Fig. 196.)

Guthrie's Method.—This is, I think, upon the whole, the best mode of amputating at the hip-joint, and it is that which I have myself employed in the four cases in which I have had occasion to perform this operation. The flaps are similar in shape and size to those made by Béclard's method, but they are

cut from without inwards, and can thus be formed more regularly. A comparatively small knife is employed—a four-inch blade is quite sufficient—and the posterior flap should be made first that its line may not be obscured by bleeding from the anterior. The incision is begun a little above the trochanter, carried downwards and across the back of the limb in a curved line convex downwards, and terminated in front of the tuber ischii; the anterior flap is marked out by a corresponding incision beginning and ending at the same points, and crossing the front of the thigh at least five inches below the joint. The skin having retracted, the muscles, first of the back and afterwards of the front of the limb, are divided in an oblique manner from below upwards (Fig. 197) till the joint is reached, when disarticulation

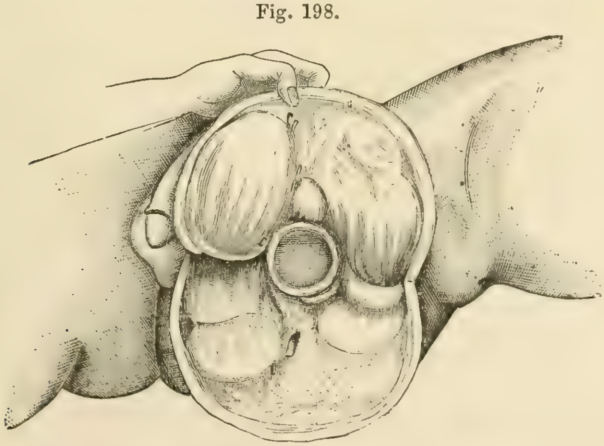
Fig. 197.



Amputation at hip-joint by Guthrie's method.

is affected in the ordinary manner. Fig. 198 shows the appearance of the wound after the amputation has been completed. This operation affords an

Fig. 198.



Wound resulting from hip-joint amputation by Guthrie's method.

excellent stump, with a small and well-protected cicatrix, as seen in Fig. 199, from the photograph of a patient whose thigh I amputated at the hip-joint for a very large osteo-sarcoma, some years since at the Episcopal Hospital.

Fig. 199.

Result of hip-joint amputation by Guthrie's method.

Lateral Flap Method.—In this form of operation, the flaps, as the name implies, are taken from the *sides* of the limb instead of from its front and back. Here, too, we may enumerate three varieties of the operation, viz., Larrey's, Lisfranc's, and Dupuytren's.

Larrey's Method.—Larrey began by exposing and tying the femoral artery just below Poupart's ligament. The surgeon introduces the point of his knife on the front of the limb, a few fingers' breadth to the inner side of and below the anterior iliac spine, pushes it backwards till it strikes the anterior face of the bone, then inclines it towards the median line of the body, so as to graze the inner surface of the cervix femoris, and, finally, effects transfixion below the tuber ischii. An internal flap, four inches long, is next cut, as in Delpech's method, and, after disarticulation, a corresponding external flap is cut in the same manner.

The elder Blandin's method differed from Larrey's simply in the formation of both flaps before attempting disarticulation.

Lisfranc's Method.—In this operation, the surgeon employs a double-edged knife, transfixes on the *outer* side of the femur, and thus cuts the external flap before the internal. As each flap is formed, he proceeds to tie the bleeding vessels, before proceeding to the other steps of the operation.

Dupuytren's Method.—This differs from Larrey's method in that the internal flap is cut from without inwards, the joint being then opened and the head of the femur turned out, when the external flap is made in the ordinary manner.

These lateral flap operations give rather unwieldy stumps, and seem to me less desirable than the other methods which have been described in the preceding pages.

The most pressing risk, in any amputation at the hip-joint, is that of hemorrhage, for a very few jets from the femoral artery will reduce any patient to a state from which he is not likely to rally. Hence special precautions should invariably be adopted against bleeding, in this operation. As already mentioned, Larrey directed that the main vessel should always be tied in the groin as a preliminary step to hip amputation, and if there be no efficient means at hand for restraining hemorrhage during the operation, such a course will be found advantageous. But under ordinary circumstances, it is, I think, better to dispense with preliminary ligation; the separation of the vessel from the surrounding tissues, which is unavoidable when an artery is tied in its continuity, cannot but expose the patient to more danger of secondary hemorrhage, following the operation, than when the cut end of the vessel is simply picked up with tenaculum or forceps as in other cases. Hence, when it is practicable, I advise that the surgeon should rely upon compression with an aortic tourniquet or other mechanical means of controlling the cir-

culation, or, if these are wanting, that he should trust to manual pressure exercised by intelligent assistants. The simplest and best form of aortic tourniquet is that of Prof. Lister (Fig. 112); the instrument employed by Prof. Joseph Pancoast (who was the first to use, in 1860, mechanical compression for restraining hemorrhage during this operation) is equally efficient, but more complicated and less readily adjusted. Prof. Spence prefers to compress the aorta by simply laying over it a thick pin-cushion, and keeping it in place by the pressure of an elastic bandage which is made to surround the body.

Although there can be no question as to the advantage derived from the use of the aortic compressor in hip-joint amputations, yet, at the same time, the pressure which must necessarily be made upon the nervous structures of the abdomen, cannot but be undesirable, if not actually harmful; hence no time should be lost in securing the vessels after the limb has been severed, so that the abdominal compression may be relaxed as soon as possible. The point at which the pad of the tourniquet is to be placed, is on a level with the navel, and usually somewhat to its left side; but as the line of the aorta varies in different subjects, this must be determined by feeling for the pulsation before adjusting the instrument. If the pad be properly placed, a moderate degree of pressure will be sufficient; it is not necessary to screw the tourniquet "home," but merely to exercise enough force to completely arrest the pulsation in both iliac arteries. Before screwing down the pad, the patient should be gently rolled over upon his right side, so that his bowels (which should have been emptied by a cathartic and an enema) may fall away from the line of pressure.

If manual compression is to be employed, this may be applied over the aorta (if the patient be thin), over the external iliac, or over the common femoral artery. The hands of an assistant, too, should follow the operator's knife, and should seize the artery in the anterior flap, before, or at least, as soon as, it is divided. Dr. Woodbury, of Philadelphia, and Prof. Van Buren, of New York, have suggested, quite independently of each other, that the circulation might be controlled, during this operation, by an assistant introducing his hand into the patient's rectum, and exercising direct pressure upon the iliac artery. Following out the same idea, Mr. R. Davy, of London, has devised an ingenious "lever," to be introduced into the rectum for the same purpose, and a number of cases of hip amputation have now been reported in which Davy's lever has proved most efficient in preventing bleeding.

Not only is it essential that the circulation should be controlled on the cardiac side of the seat of operation, but it is very desirable that the patient should not lose the blood which is in the limb to be amputated. To meet this indication, Prof. Erskine Mason, of New York, advises that the part should be first rendered bloodless by the use of Esmarch's bandage and tube, and that the latter should be kept in place during the operation, so as to prevent the blood from re-entering the condemned limb; all that is lost will then be the blood *between* the elastic tube and the point of aortic compression. The practice thus suggested by Dr. Mason, I look upon as one of the greatest improvements which has ever been effected in the operation; I have adopted it myself with entire satisfaction, and strongly urge its employment whenever hip amputation is required.

A broad, flat sponge should also be provided, as recommended by Mr. Butcher, of Dublin, for application to the whole posterior flap while the surgeon is engaged in securing the principal vessels, which are in the anterior. After the operation, the stump should be closed in the customary manner,

suitable compresses being adjusted so as to keep the deep parts of the wound in apposition.

The statistics of amputation at the hip-joint have been investigated by various surgeons, among whom I may particularly mention Prof. Stephen Smith, of New York; Mr. W. Sands Cox, of Birmingham; the late Dr. G. A. Otis, of the United States Army; and Dr. A. Lüning, of Zurich. Dr. F. C. Sheppard, of Philadelphia, has at my request made extensive researches into the literature of the subject, and has succeeded in collecting 633 cases of this operation, the details of which he has arranged for me in tabular form. These statistics are much more comprehensive than any which have hitherto been published, and show very conclusively the gravity of the operation, particularly in traumatic cases.

The following summaries show the results of the operation (1) in military practice; (2) in cases of injury treated in civil life; (3) in cases of disease; (4) in cases the nature of which is not certainly known; and (5) in cases of all kinds taken together.

I. Summary of Two Hundred and Thirty-eight Cases of Hip-joint Amputation in Military Practice.

Nature of operation.	Recovered.	Died.	Undetermined.	Total.	Mortality per cent.[1]
Primary	7	89	0	96	92.7
Intermediate	4	59	0	63	93.6
Secondary	10	17	0	27	62.9
Re-amputation of thigh stump . . .	4	3	0	7	42.8
Not stated	5	39	1	45	88.6
Total number of cases . . .	30	207	1	238	87.3

II. Summary of Seventy-one Cases of Hip-joint Amputation for Injury in Civil Practice.

Nature of operation.	Recovered.	Died.	Total.	Mortality per cent.
Primary	6	25	31	80.6
Intermediate	5	7	12	58.3
Secondary	5	6	11	54.5
Re-amputation of thigh stump	4	1	5	20.0
Not stated	4	8	12	66 6
Total number of cases	24	47	71	66.1

III. Summary of Two Hundred and Seventy-six Cases of Hip-joint Amputation for Disease.

Nature of operation.	Recovered.	Died.	Undetermined.	Total.	Mortality per cent.[1]
Amputation of entire limb	136	95	14	245	41.1
Re-amputation of thigh stump . . .	20	10	1	31	33.3
Total number of cases . . .	156	105	15	276	40.2

[1] Undetermined cases omitted in computing percentages.

IV. SUMMARY OF FORTY-EIGHT CASES OF HIP-JOINT AMPUTATION FOR UNKNOWN CAUSES.

	Recovered.	Died.	Undetermined.	Total.	Mortality per cent.[1]
Number of cases	10	34	4	48	77.2

V. GENERAL SUMMARY OF SIX HUNDRED AND THIRTY-THREE CASES OF HIP-JOINT AMPUTATION FOR ALL CAUSES.

Nature of case.	Recovered.	Died.	Undetermined.	Total.	Mortality per cent.[1]
Pathological	156	105	15	276	40.2
Traumatic	54	254	1	309	82.4
Cause unknown	10	34	4	48	77.2
Total	220	393	20	633	64.1

From the preceding statistics it will be seen that, in military practice, the death-rate of primary and of intermediate amputation has reached the appalling figure of 93 per cent., or, in other words, that not one patient in fourteen recovers from the operation. In civil practice, the results of primary amputation are still very unfavorable, the mortality being over 80 per cent., or but one patient in five recovering. Hence the inference is irresistible that, except in very exceptional circumstances, as where the limb is entirely carried away by a round shot, or completely crushed at a point too high for amputation in its continuity, or where, besides the injury to the bone, the great vessels are severed—in other words where the patient is threatened with instant death as the result of his injury—primary amputation at the hip-joint should be avoided. Whenever there is the slightest chance of doing so, an effort should be made to tide the patient over the immediate risks of the injury by expectant and palliative measures, keeping amputation in reserve, if necessary, as a secondary operation. Secondary hip-joint amputation, though very grave, is comparatively a successful procedure, the mortality, in civil and military cases taken together, being somewhat over 60 per cent., or two patients out of five recovering. In non-traumatic cases (operations for necrosis, tumors, etc.), the results are still more favorable, the death-rate being less than 41 per cent., or three out of five patients recovering. Taking all cases together, the mortality is seen to be 64.1 per cent., as compared with a death-rate of 63.8 per cent. for all amputations through the continuity of the thigh,[2] thus confirming the general rule that the gravity of amputation increases as the site of operation is in closer proximity to the trunk.

In every class of cases, but particularly in cases of injury, re-amputation after previous amputation through the thigh, is much less fatal than when the whole lower extremity is removed at once; this is easily understood when we reflect that the shock to the system of such a re-amputation is necessarily much less severe than when the patient, seeking to avoid imminent death, submits to what Hennen[3] calls the "tremendous alternative" of losing at one operation nearly a fourth of the whole body.

[1] Undetermined cases omitted in computing percentages.
[2] See Table, page 630. [3] Op. cit., p. 30.

Table of Six Hundred and Thirty-three Cases of Hip-joint Amputation.

By Frederick C. Sheppard, M.D.

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
1	Adams	1854	Fibro-cystic disease of thigh	Ant.-post. flaps	Died, 12th day. Diarrhœa	Lancet, 1854, i. 442.
2	Agnew	1866	Gunshot fracture of right femur	Secondary. Modified circular	Died, 10 days	Otis, No. 17, p. 64.
3	Alexander, T.	1854	Gunshot fracture of femur	Primary	Died, 1 month	Ibid., No. 14, p. 56.
4	do.	1854	Gunshot fracture of femur	Primary	Died, 21 days	Ibid., No. 15, p. 56.
5	do	1854	British soldier in Crimea	Primary	Died	Circ. No. 2, S. G. O., p. 109.
6	Alexander, Wm.	1875	Necrosis of femur. Pyæmia	Ant.-post. flaps	Recovered	Lancet, 1879, ii. 544.
7	do.	1877	Coxalgia. Previous excision and re-excision	Ant.-post. flaps	Recovered. Died, 18 months later	Ibid.
8	do.	1878	Coxalgia. Previous excision. Extensive disease of femur and acetabulum	Ant.-post. flaps	Recovered	Ibid.
9	do.	1879	Coxalgia. Excision immediately preceding amputation. Femur extensively diseased	Ant.-post. flaps	Recovered	Ibid.
10	Alford	1866	Tumor of left thigh	Ant.-post. flaps	Recovered	Ibid., 1869, i. 47.
11	Allen	1862	Coxalgia.	....	Recovered	Trans. Penna. State Med. Soc., 3d S., 1862, ii. 209.
12	Amerman	1862	Necrosis	Modified flap	Died, 7th day	Chicago Med. Journ., 1862, vi. 551.
13	Annandale	1869–70	Long-standing ulceration of leg and thigh	Circular	Died, 5th day	Edin. Med. Journ., 1870, xv. pt. 2, p. 883.
14	do.	1869–70	Cancerous tumor of femur	Modified flap	Died, 5th week. Heart-clot	Ibid.
15	Arlaud	1859	Gunshot fracture of right femur	Secondary	Recovered	Roux, de l'Ostéomyélite, Obs. xxviii.
16	Armstrong	1879	Coxalgia. Previous excision	Ant.-post. flaps	Died, 9 days	Br. Med. Journ., 1879, ii. 687.
17	Arnold	1831	Gunshot injury	Primary. Single internal flap	Died, 3 days	Lüning, No. 67, Hug, Obs. 46.
18	Ashhurst	1868	Gunshot wound of head and neck of right femur, and acetabulum	Secondary. Ant.-post. flaps	Died, $3\frac{1}{4}$ hours	Am. Journ. Med. Sci., 1869, lvii. 94.
19	do.	1877	Railway crush of right thigh	Primary. Ant.-post. flaps	Died, 7 hours	Operator.
20	do.	1877	Osteo-sarcoma of right thigh	Ant.-post. flaps	Recovered	Id.
21	do.	1879	Railway crush of right thigh and left leg	Primary. Ant.-post. flaps	Recovered	Id.
22	Badley	1814	Thigh crushed by machinery	Primary	Died, following day	Smith, N. Y. Journ. Med., Sept. 1852.
23	Baffos	1812	Coxalgia. Cotyloid cavity diseased	Lateral flaps	Died, three months	Richerand, Nosographie Chirurgicale, t. iv. 518.

CASES OF HIP-JOINT AMPUTATION.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
24	Baillie	1867	Compound comminuted fracture of right femur	Primary. Circular	Died from hemorrhage, 20th day	Indian Med. Gaz., Calcutta, 1869, iv. 261.
25	do.	1869	Malignant disease of leg and thigh	Ant.-post. flaps	Died from cholera, 7 weeks	Ibid.
26	Baker	1872	Intra-osseous necrosis of left femur. Spontaneous fracture	Flap operation	Recovered	Med.-Chir. Trans., lx. 187.
27	do.	1872	Malignant disease of left femur	Ant.-post. flaps	Recovered	Lancet, 1872, ii. 410.
28	do.	....	....	....	Undetermined	Ibid., 1879, i. 405.
29	Barnes	1867	Fracture and dislocation of right femur. Attempt at excision	Ant.-post. flaps	Recovered	Ibid., 1868, i. 90.
30	Baroffio	1848	(After insurrection in Lombardy)	Intermediate	Died	Circ. No. 2, S. G. O., 1869, p. 110.
31	Barwell	1872	Coxalgia. Previous excision	....	Recovered	Lancet, 1873, i. 501.
32	do.	....	Malignant disease of femur	Single internal flap	Undetermined	Br. Med. Journ., 1875, i. 787.
33	do.	1879	Coxalgia. Previous excision	....	Died, 4 hours	Ibid., 1879, ii. 686.
34	Bateman	1863	Gunshot fracture of femur	Intermediate	Died, 36 hours	Otis, No. 27, p. 62.
35	do.	1863	Comminuted fracture of femur by a shell	Intermediate	Died, 6 days	Ibid., No. 28, p. 62.
36	Baudens	183[illegible]	Gunshot comminuted fracture. Extensive suppuration	Intermediate. Anterior flap	Recovered	Ibid., No. 5, p. 60.
37	do.	1848	Gunshot fracture of femur	Primary. Anterior flap	Died following day	Ibid., No. 11, p. 56.
38	Beatson	1853	Gunshot comminution of neck of femur	Intermediate. Ant.-post. flaps	Died	Ibid., No. 7, p. 60.
39	do.	1868	Compound fracture	Intermediate. Ant.-post. flaps	Recovered	Med. Times and Gaz., 1868, ii. 124.
40	Beck	1849	Gunshot wound	Primary. Ant.-post. flaps	Died, 5th day. Hemorrhage	Arch. Klin. Chir., Berlin, 1879, xxiii. 654.
41	do.	1855	Osteo-myelitis after thigh amputation	Reamputation. Modified flap	Recovered	Ibid.
42	do.	1870	....	Primary	Died, 24 hours	Lüning, No. 434.
43	do.	1878	Previous thigh amputation for disease of knee-joint, and reamputation for osteo-myelitis	Reamputation. Modified flap	Recovered	Arch. Klin. Chir., Berlin, 1879, xxiii. 654.
44	Beddard	1879	(Patient in Nottingham Hospital)	....	Recovered	Br. Med. Journ., 1879, i. 704.
45	Bell	1877	Fibroma and enchondroma of thigh	....	Recovered	Ibid., 1878, i. 305; Edin. Med. Journ., 1877, xxiii. 261.
46	Bellamy	1879	Coxalgia. Previous excision	....	Recovered	Br. Med. Journ., 1880, ii. 624.
47	Bentley	1864	Gunshot fracture of femur	Intermediate. Ext. and int. flaps	Died, 8 days	Otis, No. 33, p. 22.

CASES OF HIP-JOINT AMPUTATION.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
48	Bentley	1864	Gunshot fracture of upper extremity of femur	Secondary. Lateral flaps	Died, 23 days	Otis, No. 11, p. 64.
49	do.	1865	Gunshot fracture of left femur	Secondary. Ant.-post. flaps	Recovered	Ibid., No. 15, p. 64.
50	Bertherand	1836–40	Probably gunshot injury	Primary	Died	Circ. No. 7, S. G. O., p. 13; Lüning, No. 87.
51	do.	1857	Gunshot injury of neck of femur	Intermediate	Died from shock	Circ. No. 2, S. G. O., p. 110.
52	do.	1859	Comminuted fracture of femur by a fragment of shell	Intermediate. Single anterior flap	Died, 3 hours	Otis, No. 16, p. 61.
53	Billroth	1860–67	Railway crush of right thigh	Primary	Died	Lüning, No. 342.
54	do.	1860–67	Right thigh crushed by beam	Intermediate	Died	Ibid., No. 343.
55	Blackman	1855	Osteo-cephaloma	....	Recovered	Circ. No. 7, S. G. O., p. 18.
56	do.	1862	Comminution of femur by fragment of shell	Intermediate Ant.-post. flaps	Died, 6 days	Otis, No. 21, p. 61.
57	do.	1866	Gunshot fracture of right femur	Secondary. Lacauchie's method	Recovered	Ibid., No. 16, p. 64.
58	Blandin, A.	1794	Gunshot fracture (?)	....	Recovered	Velpeau, Méd. Opératoire, t. ii. 539.
59	do.	1794	Gunshot fracture (?)	....	Recovered	Ibid.
60	do.	1794	Gunshot fracture (?)	....	Died, 58th day	Ibid.
61	Blandin, P. F.	1832	Malignant tumor. Spontaneous fracture	....	Died, 9th day	Ibid., p. 541.
62	Blewitt	1870	Gunshot injury at Sedan	....	Died	Langenbeck, Surg. Obs. on Gunshot Wounds of the Hip-joint. Birmingham, 1876.
63	Blicke	1815	Osteo-myelitis and abscess from gunshot wound	Secondary	Died, 8 days	Otis, No. 5, p. 63.
64	Boeckel	....	Osteo-sarcoma of femur	....	Recovered	Index Medicus, Feb. 1881, p. 80.
65	do.	1869	Coxalgia	Ant.-post. flaps	Recovered	Gaz. des Hôpitaux, 1870, pp. 25, 29.
66	Boisseré	1841	....	Reamputation	Recovered	Lüning, No. 99.
67	Bohme	1870	Gunshot fracture of upper portion of femur. Violent hemorrhage	Primary (?). Oval method	Died during operation	Ibid., No. 423.
68	do.	1870	Gunshot injury	....	Died in several days	Ibid., No. 424.
69	Bradbury	1851	Diseased thigh stump	Reamputation. Three flaps	Recovered	Boston Med. and Surg. Journ., June, 1852.
70	Brainard	1837	Malignant tumor following fracture	Circular	Died, 48 days. Hemorrhage.	Am. Journ. Med. Sci., 1838, xxii. 372.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
71	Bramwell	1872	Malignant disease of left femur	Ant.-post. flaps	Recovered. Died in 5 months from secondary deposits in lungs.	Edin. Med. Journ., 1872, xviii. 434.
72	Brashear	1806	....	... ...	Recovered	N. O. Med. and Surg. Journ., 1845–46, ii. 112.
73	Brock	1864	Left thigh completely carried away by a fragment of shell	Primary	Died, ½ hour	Otis, No. 39, p. 58.
74	Brodie	1815	Gunshot fracture of femur	....	Died	Velpeau, op. cit., ii. 541.
75	Bromfield	....	....	....	Died, 40 hours	Lancet, 1824, iii. 69.
76	Brooeke	....	....	....	Died	Lüning, No. 27.
77	Browne	1858	Disease of femur following fracture	Ant.-post. flaps	Died, 12 hours	Dublin Journ. Med. Sci., 1858, xxv. 479.
78	Brownley	....	....	....	Died	Lancet, 1824, iii. 69.
79	Brownrigg	1811	Gunshot fracture of femur	Secondary. Ant.-post. flaps	Died, 8 days	Otis, No. 1, p. 63.
80	do.	....	(During Peninsular war)	....	Died	Circ. No. 7, S. G. O., p. 11.
81	do.	....	(During Peninsular war)	....	Died	Ibid.
82	do.	1812	Gunshot fracture of femur	Secondary	Recovered	Otis, No. 2, p. 63.
83	Bruns	1844	Osteo-sarcoma of femur	....	Recovered	Lüning, No. 106.
84	do.	1846	Cancer of thigh	....	Died, 15 days	Ibid., No. 111.
85	do.	1861	Necrosis and coxalgia. Previous excision	....	Died	Ibid., No. 262.
86	do.	1861	Enormous malignant tumor of femur	Oval method	Died, 6 weeks	Ibid., No. 263.
87	Bryant	....	Tumor of neck of femur	....	Undetermined	Br. Med. Journ., 1880, i. 697.
88	Bryce	1827	Gunshot fracture of femur. Extensive laceration of soft parts	Primary. Ant.-ext. and post.-int. flaps	Recovered	Glasgow Med. Journ., 1831, iv. 262.
89	Buchanan, A.H.	1859	Necrosis of femur. Spontaneous fracture	Ant.-post. flaps	Recovered	Nashv. Med. and Surg. Jr., 1859.
90	Buchanan, G.	....	Malignant tumor of femur	....	Died, 15 days. Secondary deposits in lungs	Glasgow Med. Journ., 1873, v. 462.
91	Buck	1864	Diseased stump after thigh amputation for gunshot injury	Reamputation. Ant.-post. flaps	Died, 24 hours	Otis, No. 2, p. 65.
92	Buel	1847	Railway crush of thigh	Primary	Died within 24 hours	Am. Journ. Med. Sci., 1848, [xvi. 34.
93	Buist	1864	Femur shattered by cannon ball	Primary. Ant.-post. flaps	Died, 36 hours	Otis, No. 43, p. 59.
94	Burnard	1833	Complicated fracture	....	Died	Lüning, No. 76.
95	Busch	....	Tumor of bone	....	Recovered	Ibid., No. 260.
96	do.	....	Tumor of bone	....	Recovered	Ibid., No. 261.
97	do.	1861	Comminuted fracture. Gangrene	....	Died, 48 hours	Ibid , No. 259.
98	do.	1866	....	....	Died	Ibid., No. 373.
99	do.	1870	Gunshot injury	....	Died	Langenbeck, op. cit.
100	do.	1870	Gunshot injury	....	Died	Ibid.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
101	Butcher	1857	Osteo-sarcoma of leg and thigh	Ant.-post. flaps	Died	Dublin Journ. Med. Sci., 1866, xlii. 305.
102	Cadge	1879	Osteo-sarcoma. Fracture of lower third of femur	....	Recovered. Died, 2 mos. pulmonary sarcoma.	Br. Med. Journ., 1879, ii. 686.
103	Callender	....	....	....	Died	St. Bartholomew's Hosp. Reps., 1878, xiv. 192.
104	Carmichael	1819	Osteo-sarcoma	....	Died, 5th day	Dublin Journ. Med. Sci., 1866, xlii. 298.
105	Carnochan	1864	Thigh completely shattered by a shell	Primary. Modified flap	Died, 10 hours	Otis, No. 40, p. 59.
106	Carothers	1871	Gunshot wound of thigh	Ant.-ext. and post.-int. flaps	Recovered	Am. Journ. Med. Sci., 1873, lxv. 92.
107	Chaillé	....	Gunshot injury	... .	....	Circ. No. 2, S. G. O., 1869, p. 109.
108	Chase	1864	Gunshot comminution of neck and trochanters of femur; compact tibia and fibula	Primary. Béclard's method	Died, 12 hours	Circ. No. 2, S. G. O., pp. 107, 108.
109	Chassaignac	1860	....	....	Recovered	Lüning, No. 254.
110	Chaumet	1840	Medullary sarcoma	....	Died	Ibid., No. 96.
111	Chelius	1845	Malignant disease	....	Died	Ibid., No. 109.
112	do.	1853	Necrosis after thigh amputation	Reamputation	Died, 9 days	Ibid., No. 162.
113	Cherubini	1832	....	Delpech's method	Died	Ibid., No. 69.
114	Clark, E. M.	1853	Fungus hæmatodes	Single flap	Died, 41 days	Penins. Journ. Med., i. 59.
115	Clark, Le G.	1866	Malignant disease of thigh stump	Reamputation. Long anterior flap	Recovered	Lancet, 1867, i. 11.
116	Clot Bey	1830	Gunshot fracture of femur	Secondary. Single internal flap	Died, 8 days	Otis, No. 6, p. 63.
117	Cole	1814	Gunshot fracture of upper extremity of femur	Secondary. Circular	Died, 20 hours	Ibid., No. 3, p. 63.
118	Compton	1862	Femur shattered by a cannon ball	Primary. Single flap	Died, 8 days	Ibid., No. 31, p. 58.
119	do.	1863	Trochanters and neck of femur smashed by a shell	Primary. Single internal flap	Recovered	Ibid., No. 33, p. 58.
120	do.	1863	Comminution of femur and fracture of tuberosity of ischium by fragment of shell	Primary. Large anterior flap	Died, 1 hour	Ibid., No. 35, p. 58.
121	Cooper, A.	1824	Disease of femur	Reamputation	Recovered	Lancet, 1824, ii. 96.
122	do.	....	....	....	Died	Circ. No. 7, S. G. O., p. 17.
123	Cooper, Saml.	1814	Fracture of upper part of femur by a grape [shot	Intermediate. Circular	Died in a few minutes	Otis, No. 3, p. 59.
124	Couper	1867	Malignant disease (man)	....	Recovered	Lancet, 1870, ii. 816.
125	do.	1867	Malignant disease (woman)	....	Recovered	Ibid.
126	Cowell	1879	Coxalgia	....	Recovered	Br. Med. Journ., 1879, ii. 686.

CASES OF HIP-JOINT AMPUTATION.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
127	Cox, Wm. Sands	1844	Disease of stump after previous thigh amputation	Reamputation	Recovered	Cooper, Surg. Dict., ed. by Lane, i. 117.
128	Crymes	1862	Gunshot fracture of trochanter major and neck of femur	Intermediate. Ant.-post. flaps	Died, 3 days	Otis, No. 25, p. 62.
129	Cumming	1873	Coxalgia in a man aged 20 years	Ant.-post. flaps	Recovered	Lancet, 1873, ii. 772.
130	Cunningham	1877	Osteo-sarcoma of left femur. Spontaneous fracture	Circular	Recovered	Virgin. Med. Month., 1877, iv. 498, 505.
131	Curling	1856	Medullary cancer of thigh	Ant.-post. flaps	Recovered. Died of an internal disease in ten months	Lancet, 1857, i. 6; Dublin Journ. Med. Sci., 1866, xlii. 303.
132	do.	1863	Caries of head and neck, with necrosis of shaft of femur	Double flaps	Died, 5 weeks	Lancet, 1865, i. 566.
133	do.	1866	Coxalgia	....	Recovered	Lond. Hosp. Rep., 1866, iii. 214; iv. 518.
134	Cutcliffe	1869	Boy with necrosis of femur	Ant.-post. flaps	Recovered	Indian Med. Gaz., Calcutta, 1870, v. 11.
135	Davis	1863	Thigh nearly torn off by shrapnel. Free hemorrhage	Primary. Single anterior	Died, 2 hours	Circ. No. 2, S. G. O., 1869, p. 108.
136	Davy	1877	Boy with coxalgia	Square ant. flap	Recovered	Br. Med. Journ., 1878, i. 704.
137	do.	1879	Coxalgia. Previous excision	....	Recovered	Ibid., 1879, ii. 686.
138	Dawson	1880	Caries. Previous excision	Circular	Undetermined	Med. and Surg. Reporter, Phila., 1880, xlii. 206.
139	De Bruler	1862	Crush of upper portion of femur by musket ball	Intermediate. Lisfranc's method	Died, 1 hour	Otis, No. 22, p. 61.
140	De Morgan	1870	Malignant disease of femur	Modified circular	Recovered	Med. Times and Gaz., 1870, i. 177.
141	Delpech	1824	Necrosis of femur. Abscess	Lateral flaps	Recovered	Smith, loc. cit., p. 194.
142	do.	1827	Comp. fracture followed by extensive suppuration	Secondary. Single internal flap	Died in 6 months from chronic peritonitis	Ibid.
143	Demme, Sen.	1845	Osteo-myelitis and necrosis	Oval method	Recovered	Lüning, No. 108.
144	do.	1831	Polish soldier. Gunshot injury	Intermediate. Single internal flap	Died, 5 days. Gangrene	Hug. Obs. 13; Lüning, No. 65.
145	do.	1831	Polish soldier. Gunshot injury	Intermediate. Int. flap	Died, 13 days	Lüning, No. 66.
146	do.	1831	Polish soldier. Gunshot injury	Intermediate	Died	Circ. No. 7, S. G. O., p. 13.
147	Demons	....	Necrosis of femur	....	Recovered	Index Medicus, Feb. 1881, p. 80.
148	Désormeaux	1870	Gunshot wound of great trochanter. Amputation necessitated by hemorrhage	Primary	Died without reaction	Bull. et Mém., Soc. de Chir. de Paris, 1878, iv. 100.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
149	Desprès	....	Crushed hip	Primary. Ant. flap	Died, 48 hours	Bull. et Mém., Soc. de Chir. de Paris, 1878, iv. 99.
150	Dieffenbach	1826	Fracture through trochanters	Secondary	Died, 10 hours	Lüning, No. 54.
151	do.	1832	Osteo-sarcoma of thigh	Larrey's method	Died, 13th day	Ibid., No. 73; Hug, Obs. 17.
152	Dubois	1867	Gunshot wound of neck of femur	Secondary. Ant.-post. flaps	Died, 30 hours	Otis, No. 19, p. 64.
153	Duffee	1840	Coxalgia	....	Recovered	Am. Journ. Med. Sci., July, 1857, p. 283; July, 1866, p. 22.
154	Dunlop	1855	Fracture of femur by splinter of shell	Primary. Double flaps	Died soon after	Otis, No. 24, p. 57.
155	Dupuytren	....	....	....	Died	Leçons Orales, 2me ed., t. ii. p. [370.
156	do.	....	....	....	Died	Ibid.
157	do.	....	....	....	Died	Ibid.
158	do.	....	....	....	Died	Ibid.
159	do.	....	....	....	Died	Ibid.
160	do.	....	....	....	Died	Ibid.
161	Duval	1858	Crush by steam engine	Intermediate	Died, 4 hours	Lüning, No. 235: Gaz. Hebdom., 1860, p. 293.
162	East	1864	Gunshot fracture of head of femur	Primary. Larrey's method	Recovered	Circ. No. 7, S. G. O., p. 76.
163	Elkington	1875	A child with necrosis of right femur	Ant.-post. flaps	Recovered	Br. Med. Journ., 1876, i. 116.
164	do.	1875	Child with coxalgia. Previous excision	....	Recovered	Ibid.
165	Emery	1814	Gunshot fracture of femur	Secondary. Lateral flaps. Larrey's method	Died, 30 days	Thomson, Report on Military Hospitals in Belgium, p. 269.
166	Encholm	1808	....	....	Recovered	Lüning, No. 9.
167	Erichsen	1855	Railway crush of thigh	Primary. Ant.-post. flaps	Died in a few hours	Lancet, 1866, i. 221.
168	do.	1865	Encephaloid of femur	Ant.-post. flaps	Recovered	Ibid.
169	do.	1870–73	....	....	Died	Ibid., 1874, i. 84.
170	Esmarch	1869	Periostitis and osteo-myelitis of femur	Modified circular	Recovered	Berl. klin. Wochenschr., 1872, ix. 370.
171	do.	1871	Osteo-sarcoma of femur	Flap operation	Died, 10 days	Ibid.
172	Eve	1871	Caries of femur	Ant.-post. flaps	Died, 25 hours	Nashville Journ. Med. and Surg., 1871, N. S., viii. 49–56.
173	Fauntleroy	1865	Caries after amputation of thigh for gunshot wound	Reamputation. Ant.-post. flaps	Recovered	Otis, No. 5, p. 65.
174	Favell	1864	Encephaloid of thigh	Ant.-post. flaps	Recovered	Lancet, 1865, i. 567.
175	Fayrer	1853	Gunshot fracture of neck and trochanters of femur	Primary. Ant.-post. flaps	Died of tetanus, 1 month	Edin. Med. Journ., 1871, xvi. 803–805.
176	do.	1864	Osteo-myelitis after previous thigh amputation for injury	Reamputation. Ant.-post. flaps	Recovered	Ibid.

CASES OF HIP-JOINT AMPUTATION.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
177	Fayrer	1867	Gunshot fracture of head and neck of femur	Intermediate. Ant.-post. flaps	Died, 3 hours	Edin. Med. Journ., 1868, xiii. 793.
178	do.	1865	Previous amputation of thigh. Osteo-myelitis and pyæmia	Reamputation. Ant.-post. flaps	Died of pyæmia	Ibid., 1871, xvi. 803–805.
179	do.	1866	Medullary carcinoma of knee and thigh. 5 years' duration	Ant.-post. flaps	Died of pyæmia	Ibid.
180	do.	1867	Previous amputation of thigh for injury. Osteo-myelitis	Reamputation. Ant.-post. flaps	Died of heart-clot, 26 hours	Ibid.
181	do.	1868	Shark bite	Primary. Int. and ext. flaps	Died, 6 hours	Ibid.
182	do.	1868	Cancer of thigh	Ant.-post. flaps	Died from exhaustion, 5 days	Ibid.
183	Felton	1862	Gunshot fracture of neck of femur	Intermediate	Died, 1 hour	Otis, No. 23, p. 62.
184	Forbes	1866	Disease of femur following gunshot wound	Modified circular	Died	Episcopal Hospital Register.
185	Foulis	1877	Coxalgia	Modified circular	Recovered	Lancet, 1877, ii. 763.
186	Foullioy	1841	Osteo-sarcoma of femur	....	Recovered	Lüning, No. 100.
187	Francke	1831	Gunshot comminution of femur	Primary. Single internal flap	Died, 2 days	Ibid., No. 68.
188	Frank	1870	Gunshot injury	Primary	Died	Langenbeck, op. cit.
189	do.	1870	Gunshot injury	Secondary	Died	Ibid.
190	Franklyn	1855	Comminuted fracture of femur. Gunshot	Primary	Died, 22 hours	Otis, No. 23, p. 57.
191	Fricke	1830 (?)	....	....	Died, 6 hours	Lüning, No. 58.
192	Gallozzi	....	Large myxo-sarcoma	Circular	Recovered	Ibid., No. 475.
193	Gamgee	1865	Enormous tumor of thigh	....	Recovered	Edin. Med. Journ., 1866, xii. 64.
194	Gant	1868	Compound comminuted fracture of femur	Primary. Oval	Died, 3 hours	Br. Med. Journ., 1868, i. 611.
195	Garden	1880	Coxalgia. Previous excision	....	Recovered	Ibid., 1880, i. 626.
196	Gay, J.	1878	Coxalgia. Previous excision	....	Recovered from operation	Lancet, 1878, i. 787.
197	Gay, G. W.	1878	Enchondroma	Modified flap	Died, 4th day	Boston Med. and Surg. Journ., 1879, c. 395.
198	Gensoul	....	....	....	Died	Velpeau, op. cit.
199	Gerdy	1824	Cancer of thigh. Dangerous hemorrhage	....	Died, 9th day	Smith, loc. cit., p. 194.
200	Gherini	1859	(In the Italian war)	Intermediate	Died	Circ. No. 2, S. G. O., p. 109.
201	Gibb	....	Malignant disease of femur	....	Undetermined	Br. Med. Journ., 1874, i. 205.
202	Gilgencrantz	1854	Gunshot comminution of neck of femur	Intermediate	Died in a few hours	Circ. No. 2, S. G. O., 1869, p. 110
203	Gill	1865	Gunshot fracture of femur through trochanters	Primary. Double flaps	Died, 7 hours	Otis, No. 44, p. 59.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
204	Gilliam	1880	Crush of lower extremity from ankle to groin	Primary. Single post. flap	Died, 23 hours	Operator.
205	Gilmore	1862	Gunshot fracture of femur	Primary. Ant.-post. flaps	Prob. recovered. Stump healed in 6 weeks	Otis, No. 28, p. 57.
206	do.	1862	Gunshot fracture of femur	Primary. Ant.-post. flaps	Died, 1 hour	Ibid., No. 29, p. 57.
207	do.	1862	Gunshot fracture of neck and trochanters of femur	Primary. Ant.-post. flaps	Died, 2 days	Ibid., No. 30, p. 58.
208	Godfray	1863	Necrosis of femur extending into hip	Flap operation	Recovered	Lancet, 1865, i. 652.
209	Goodwin	1864	Gunshot fracture of upper third of femur	Intermediate. Ant.-post. flaps	Died, 2 hours	Otis, No. 32, p. 62.
210	Gorgas	1864	Gunshot fracture of upper part of left femur	Primary. Ant.-post. flaps	Died, 2 hours	Ibid., No. 38, p. 58.
211	Gould	1878	Advanced coxalgia. Previous excision	Oval method	Died, 68 hours	Tr. Clin. Soc. Lond., 1879, xii. 167.
212	Graefe	....	....	....	Died	Circ. No. 7, S. G. O., p. 16.
213	Grant	1862	Gunshot fracture of femur	Primary. Lisfranc's method.	Probably died	Otis, No. 32, p. 58.
214	Gray	1863	Gunshot fracture of upper part of femur. Operation necessitated by hemorrhage	Intermediate. Ant.-post. flaps	Died, 4 days	Circ. No. 2, S. G. O., 1869, p. 109.
215	Griswold	1865	Gunshot fracture of femur	Intermediate. Double flaps	Died, 1 hour	Otis, No. 34, p. 62.
216	Gross, S. D.	1862	Loss of integument and suppuration following burn	Flap-method	Recovered	Am. Journ. Med. Sci., Jan. 1864.
217	do.	1865	Medullary sarcoma of thigh	Circular	Recovered	Phot. Rev. Med. and Surg., Phila., 1871–72, ii. 29–31.
218	do.	1879	Sarcoma of thigh	Flap operation	Recovered	Phila. Med. Times, 1880, x. 517.
219	Gross	1879	Cysto-sarcoma in triceps femoris	Verneuil's method	Operation successful. Died from return of disease	Le Progrès Médical, Paris, 1880, viii.
220	Guersant	1847	Malignant tumor of femur	....	Died in 21 days of pyæmia	Lüning, No. 115; Hug. Obs. 32.
221	do.	1848	Gunshot wound	Intermediate	Died	Legouest, Chir. d'Armée, p. 700.
222	do.	1848	Cancer of femur in a child	....	Recovered	Otis, p. 16; Smith, loc. cit.
223	Guthrie, C. G.	1853	Malignant disease of femur	....	Died, 2d day	Lancet, 1853, i. 405.
224	Guthrie, G. J.	1812	Sloughing stump after thigh amputation	Reamputation. Oblique method	Died, 7 hours	Guthrie, Commentaries, p. 17.
225	do.	1815	Femur shattered by a cannon ball	Intermediate. Guthrie's oblique method	Recovered	Ibid.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
226	Guyon	1836–40	(During French campaign in Algeria)	Primary	Died	Lüning, No. 86; Circ. No. 7, S. G. O., p. 13.
227	do.	1874	Osteo-sarcoma of femur	....	Recovered. Died in 6 months of cancer of lungs	Bull. Soc. Anat., Paris, 1874, ix. 408, 862.
228	Hachenburg	1861	....	....	Died	Circ. No. 7, S. G. O., p. 18.
229	Hamilton	1866	Non-traumatic osteitis, osteo-myelitis, and periostitis of thigh and leg	Reamputation	Died, 7th day	N. Y. Med. Journ., 1867, iv. 285.
230	Hancock	1852	Compound fracture of leg, thigh, and arm. Erysipelas and gangrene on 17th day	Intermediate	Died from shock	Lancet, 1857, i. 31.
231	do.	1856	Extensive disease of thigh and entire femur	Ant.-post. flaps	Recovered	Ibid.
232	do.	1860	Disease of thigh stump after two amputations	Reamputation. Ant.-post. flaps	Died, 12 hours	Ibid., 1860, i. 319.
233	Handyside	1843	Osteo-medullary sarcoma of femur	Ant.-post. flaps	Recovered from operation. Died $4\frac{1}{2}$ months later from return of disease in int. organs	Lond. and Edin. Monthly Journ., 1845, v. 254.
234	Hassenburg	1864	Diseased stump after thigh amputation for gunshot fracture of knee-joint	Reamputation. Ant.-post. flaps	Died, 7 days	Otis, No. 3, p. 65.
235	Hendley	1873	Gunshot wound of thigh	Secondary. Ant.-post. flaps	Died, 20 hours	Ind. Med. Gaz., Calcutta, 1873, viii. 293.
236	Hénot	1847	Exostosis of femur. Abscess	Ant.-post. flaps. Modified Béclard	Recovered	Smith, loc. cit.
237	Hewson	1864	Railroad injury	Primary. Flap operation	Died, 12 hours	Surgery in Penna. Hospital, Phila., 1880, p. 34.
238	do.	1865	Enchondroma	Flap operation	Died without reaction	Ibid.
239	do.	1872	Malignant disease of thigh and stump	Reamputation. Flap operation	Died, 4th day	Ibid.
240	Heyfelder	1851	Caries	....	Died, 2 hours	Lüning, No. 150.
241	do.	1853	Malignant disease	Oval method	Recovered	Ibid., No. 156.
242	do.	1852–53	Disease of thigh	Guthrie's method	Recovered	Ibid., No. 159.
243	do.	1853	Disease of thigh	Oval method	Recovered	Ibid., No. 157.
244	do.	1853	Disease of thigh	Oval method	Died, 50 hours	Ibid., No. 158.
245	do.	1854	Osteitis and periosteitis	Reamputation	Died, 8 hours	Ibid., No. 168.
246	do.	1854	Caries	....	Died, 29 hours	Ibid., No. 169.
247	do.	1854	Necrosis and caries	....	Recovered	Ibid., No. 170.
248	do.	....	....	....	Died	Ibid., No. 264.
249	do.	....	....	....	Died	Ibid., No. 265.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
250	Heyfelder	....	....	....	Died	Lüning, No. 266.
251	do.	....	....	....	Died	Ibid., No. 267.
252	do.	1861	Necrosis after thigh amputation for complicated fracture	Reamputation	Died, 2 or 3 weeks	Ibid., No. 268.
253	Hill	1868 (?)	Osteo-sarcoma of femur	Ant. skin flap	Recovered. Died, 6 years later	Lancet, 1874, ii. 251; also 1875, Dec. 4.
254	Hodgen	1873	Malignant disease of femur	Ant.-post. flaps	Died, 22 hours	St. Louis Med. and Surg. Journ., 1873, N. S., x. 485.
255	Hodges	1868	Malignant tumor of thigh stump	Reamputation. Flap operation	Recovered. Disease returned in 2 years	Boston Med. and Surg. Journ., 1872, ix., Appendix, p. vi.
256	Holmes	1865	Coxalgia. Previous excision. Osteo-myelitis	Ant.-post. flaps	Died from abscesses in brain	St. George's Hosp. Reps., 1866, i. 151.
257	do.	1865	Coxalgia. Previous excision. Osteo-myelitis	....	Died. Pyæmia	Ibid., p. 152.
258	do.	1865	Recurrent fibroid disease of thigh	Ant. flap (elliptical)	Recovered. Died in 8 months, secondary deposits	Ibid., p. 138; Tr. Path. Soc., 1866, xxii. 290.
259	do.	1868	Compound comminuted fracture of femur and crush of left arm	Primary	Died in a short time	St. George's Hosp. Reps., 1869, iv. 340.
260	Housework	1877	Myeloid tumor of femur	Ant.-post. flaps	Recovered	Ibid., 1877–78, ix. 383.
261	Howard	1863	Gunshot fracture of femur extending into hip-joint	Primary. Ant.-post. flaps	Died, 48 hours	Otis, No. 37, p. 58.
262	Hueter	1870	Gunshot fracture of femur	....	Died from hemorrhage following day	Langenbeck, op. cit., p. 58.
263	Hughes	1880	Coxalgia	Double flap	Undetermined	Br. Med. Journ., 1880, ii. 993.
264	Hulke	1875	Coxalgia. Previous excision	....	Undetermined	Lancet, 1875, i. 269.
265	Humphrey	1854	Compound fracture. Gangrene	Secondary. Double flap	Recovered	Eve, Remarkable Cases in Surgery, p. 565.
266	do.	1855	Chronic disease from injury	....	Recovered	Ibid.
267	Hunter	1875	Tumor of thigh	Modified circular	Died	Register, Hosp. Univ. of Penna., 1875, No. 581.
268	Hutchinson	....	Coxalgia	....	Died	Br. Med. Journ., 1880, i. 697.
269	do.	....	Coxalgia	....	Died	Ibid.
270	do.	....	Coxalgia	....	Recovered	Ibid.
271	do.	....	Coxalgia	....	Recovered	Ibid.
272	Hutin	1836	Gunshot fracture of neck of femur	Primary. Manec's method	Died	Otis, No. 9, p. 56.
273	do.	1836	Gunshot fracture of femur	Primary. Manec's method	Died	Ibid., No. 10, p. 56.

Note.—Mr. Howse, of London, has performed this operation (Lancet, 1879, i. 597), but I am unable to find a detailed account of his cases.

CASES OF HIP-JOINT AMPUTATION.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
274	Hysern	....	....	....	Recovered	Lüning, No. 228.
275	Ingram	1864	Gunshot fracture through trochanters	Intermediate. Ant.-post. flaps	Died, 24 hours	Otis, No. 30, p. 62.
276	Isnard	1859	Gunshot injury of thigh and femur	Secondary	Recovered	Ibid., No. 8, p. 63.
277	Jackson	1871	Coxalgia. Previous excision	....	Recovered	Tr. Path. Soc. Lond., 1872, xxiii. 191.
278	Jaeger	1832	Caries of knee. Necrosis of femur	Lateral flaps	Recovered	Smith, loc. cit.
279	Jewitt	1864	Femur shattered by fragment of shell	Primary. Single ant.-int. flap	Died, 2 hours	Otis, No. 41, p. 59.
280	Jones	1849	Operation for hemorrhage from lacerated wound of thigh	Intermediate. Ant.-post. flaps	Died, 27 hours	Cooper, op. cit., vol. i. p. 118.
281	Jordan	1879	Necrosis of femur	Mod. circular	Died, 3 weeks	Lancet, 1879, i. 405, 682.
282	do.	1879	Gangrene	....	Undetermined	Br. Med. Journ., 1879, i. 704.
283	Kearney	1871	Malignant disease	....	Doing well 14 days after operation	Cincin. Lancet and Obs., 1871, N. S., xiv. 438.
284	Kerr	1778	Coxalgia. Primary amputation	....	Died, 18 days	Med. and Philosoph. Commentaries, vol. vi. p. 337.
285	Kerst	1830	....	....	Died	Lüning, No. 59.
286	do.	1830–31	....	....	Died	Ibid., No. 60.
287	Kinloch	1863	Gunshot fracture of head and neck of femur	Intermediate. Manec's method	Died, 24 hours	Otis, No. 26, p. 62.
288	Korseniewski	1834	Osteo-sarcoma of thigh	Circular	Died, 20th day	Smith, loc. cit.
289	Krimer	1822	Necrosis of femur. Gunshot fracture. Operation 7 years after wound	Larrey's method	Died, 10 days	Lüning, No. 34.
290	Lane	1857	Compound fracture of femur. Extensive injury of soft parts	Primary. Ant.-post. flaps	Died, 5 hours, from shock	Lancet, 1857, ii. 443.
291	do.	1862	Malignant disease of thigh	Ant.-post. flaps	Died, 8 weeks later from pus in femoral artery	Ibid., 1865, i. 651.
292	do.	1864	Malignant disease of femur	Ant.-post. flaps	Died in 2 months from secondary deposits in pleura	Ibid., p. 566.
293	Langenbeck	1843	Osteo-myelitis	Oval	Died, 2 days	Lüning, No. 102.
294	do.	1844	Osteo-myelitis. Spontaneous fracture	Antero-internal flap	Recovered	Ibid., No. 107.
295	do.	1848	Grenade fracture of left hip	Primary	Died, 27 days	Ibid., No. 127.
296	do.	1848	Gunshot fracture of cervix femoris	Intermediate	Died, 6 days	Ibid., No. 128.
297	do.	1848	Gunshot fracture of femur	Primary	Recovered	Ibid., No. 129.
298	do.	1848	Gunshot fracture of femur	Secondary	Died, 30 hours	Ibid., No. 130.
299	do.	1864	Gunshot fracture of right femur	Primary	Died, 5 days	Ibid., No. 311.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
300	Langenbeck	1864	Gunshot fracture of femur	Intermediate. Ant.-int. flap	Died, 8 days	Lüning, No. 312.
301	do.	1866	Gunshot fracture of left femur	Intermediate	Died, 4 days	Ibid., No. 369.
302	do.	1866	Gunshot fracture of right femur	Intermediate	Died, 7 days	Ibid., No. 370.
303	do.	1867	Osteo-sarcoma of left femur	Ant.-int. flap	Recovered	Ibid., No. 387.
304	do.	1874	Sarcoma of right thigh	Flap operation	Recovered	Ibid., No. 490.
305	do.	1827	....	....	Died	Ibid., No. 56.
306	Lannelongue	....	....	....	Undetermined	Ibid., No. 486.
307	Lanning	1863	Gunshot fracture of femur. Wound of artery	Primary	Died, 4 hours	Circ. No. 2, S. G. O., 1869, pp. 108–109.
308	Larivière	1855	Gunshot fracture of femur	Intermediate	Died during operation	Otis, No. 12, p. 61.
309	Larrey	1793	Gunshot fracture of femur	Primary. Larrey's method	Died within a week	Ibid., No. 1, p. 55.
310	do.	1799	Gunshot fracture of femur. Wound of artery	Primary. Larrey's method	Died of plague on 8th day	Ibid., No. 2, p. 55.
311	do.	1799	Thigh torn off by a shell	Primary. Larrey's method	Died in a few days	Ibid., No. 3, p. 55.
312	do.	1812	Femur shattered by a cannon ball	Primary. Larrey's method	Died, 29th day, from dysentery	Ibid., No. 4, p. 55.
313	do.	1812	Gunshot fracture of femur	Primary. Larrey's method	Said to have recovered	Ibid., No. 5, p. 55.
314	do.	1809	Thigh shattered by a cannon ball	Intermediate. Larrey's method	Died, 3 hours	Ibid., No. 1, p. 59.
315	do.	1809	Thigh shattered by a cannon ball	Intermediate. Larrey's method	Died within 24 hours	Ibid., No. 2, p. 59.
316	Lay	1863	Gunshot fracture of femur	Primary. Single anterior flap	Died, 1 hour	Ibid., No. 36, p. 58.
317	do.	....	Gunshot injury	Intermediate	Died	Circ. No. 2, S. G. O., 1869, p. 108.
318	do.	....	Gunshot injury	Intermediate	Died	Ibid.
319	Lee	1865	Coxalgia. Pelvis diseased. Attempt at excision	Modified circular	Recovered	St. George's Hosp. Reports, vol. i. p. 147.
320	Legouest	1854	Gunshot injury of femur	Intermediate. Single ant.-int. flap	Recovered. Fell and hurt stump. Inflammation, hemorrhage, diarrhœa, death	Gaz. Méd. de Paris, 1878, p. 72; Bull. de l'Acad. de Méd., Paris, 2me S., t. vii. p. 96.
321	do.	....	Gunshot injury	Primary. Several irregular flaps	Died shortly after	Ibid.
322	do.	....	Disease of femur	....	Undetermined	Ibid.
323	Lente	1849	Gunshot fracture of neck of femur	Primary. Lateral flaps	Died	Otis, No. 12, p. 56.
324	Letulle	1832	Gunshot fracture of femur	Primary. Int. and short post. flaps	Died	Ibid., No. 8, p. 56.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
325	Liebl	1877	Carcinoma of left femur. Previous removal of tumor	Modified flap	Died, 5 hours	Wien. med. Presse, 1877, xviii. 1574.
326	Lincoln	1871	Necrosis of femur following gunshot wound. Previous resection of 2 inches	....	Recovered	Boston Med. and Surg. Journ., 1878, xcviii. 166.
327	Linhart	1848	Gunshot wound	....	Died	Lüning, No. 124.
328	do.	1863	Complicated fracture. Railway injury	Primary. Ant.-post. flaps	Recovered	Ibid., No. 294.
329	do.	1866	Injury of thigh	Secondary	Died	Ibid., No. 372.
330	Lister	1871	Complicated fracture of both lower extremities	Primary	Died, 3 hours	Ibid., No. 458.
331	do.	1871	Crush of leg and thigh	Ant.-post. flaps	Recovered	Edin. Med. Journ., 1871, xvii. pt. i. 149.
332	do.	1872	Encephaloid of thigh	....	Died, $1\frac{1}{2}$ hours	Lüning, No. 468.
333	do.	1872	Osteo-sarcoma of thigh	....	Died, 14 hours	Ibid., No. 469.
334	do.	1873	Railway injury	Primary	Died, 10 hours	Ibid., No. 479.
335	Liston	1829	Disease of entire femur	Lateral flaps	Died, 2d day	Fergusson's Syst. Surgery, 4th ed., p. 506.
336	do.	....	....	....	Died	Ibid.
337	Littlefield	1879	(Patient at Nottingham Hospital)	....	Recovered	Br. Med. Journ., 1879, i. 704.
338	Lucas	1877	Malignant tumor of thigh following repeated fractures	Ant.-int. and post.-ext. flaps	Recovered. Died from return of disease in pelvis and lung	Guy's Hosp. Rep., London, 1879, 3 S., xxiv. 320.
339	do.	1879	Coxalgia. Previous excision	Ant.-ext. and post.-int. flaps	Doing well two weeks later	Br. Med. Journ., 1879, ii. 984.
340	Lund	1872	Tumor of knee and thigh	....	Recovered	Br. Med. Journ., 1874, i. 111.
341	Lustreman	1855	Gunshot fracture of femur	Primary	Died, 5 hours	Otis, No. 19, p. 56.
342	Lutens	....	....	....	Undetermined	Bull. de l'Acad. de Méd. de Belg., 1842, i. 85.
343	Lyon	1865	Coxalgia. Previous excision	....	Recovered	Glasgow Med. Journ., 1865, xiii. 143.
344	MacCormac	1878	Osteo-sarcoma of thigh	Ant.-post. flaps	Recovered	Br. Med. Journ., 1879, i. 8–10.
345	do.	1870	Gunshot fracture of leg and thigh	Secondary. Ant. flap	Died, probably from chloroform	Langenbeck, op. cit., and St. Thomas's Hosp. Rep., ii. 52.
346	do.	1870	Gunshot fracture of femur	Secondary	Died	Ibid.
347	do.	1870	Gunshot laceration of thigh	Secondary. Ant. flap	Died, 6 days	Ibid.
348	Macfarlane	1831	Compound fracture. Child 2 years of age	....	Recovered	Lancet, 1853, i. 406; Circ. No. 7, S. G. O., 1867, p. 17.
349	Mack	1869	Coxalgia. Unsuccessful attempt at excision. Fracture of neck of femur	Lateral flaps	Recovered	Buffalo Med. and Surg. Journ., 1870–71, x. 250.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
350	Mackenzie	....	Necrosis	....	Died	Circ. No. 7, S. G. O., p. 17.
351	Macleod	....	....	....	Recovered	Lancet, 1877, ii. 937.
352	do.	....	Malignant disease of femur	Flap operation	Recovered	Ibid.
353	Macnamara	1879	Coxalgia	....	Recovered	Br. Med. Journ., 1879, ii. 686.
354	Maisonneuve	1866	Coxalgia	....	Recovered	Lüning, No. 376.
355	Mandach	1872	Osteitis of femur	Circular	Died, 4 days	Ibid., No. 465.
356	Marcacci	1871	Enormous osteo-sarcoma	....	Recovered	Ibid., No. 456.
357	Marjolin	1862	Girl with white swelling	....	Recovered (?)	Ibid., No. 273.
358	Marmy	1847	Osteitis of right femur	Posterior flap	Undetermined	Bull. de la Soc. Anat., Paris, 1848, xxiii. 27.
359	Marriott	1863	Fibro-plastic tumor of thigh	Ant.-post. flaps	Recovered	Br. Med. Journ., 1863, ii. 342.
360	Marroin	1854–55	Gunshot fracture of great trochanter (French fleet in Crimea)	....	Died	Lüning, No. 218.
361	Marshall	1879	Coxalgia. Previous excision	Jordan's method	Died, 3 months	Lancet, 1880, i. 57.
362	do.	1879	Coxalgia. Previous excision	Jordan's method	Recovered	Ibid.
363	do.	1879 (?)	Coxalgia. Previous excision	Jordan's method	Recovered	Ibid., p. 788.
364	do.	1879 (?)	Primary operation for coxalgia	Jordan's method	Recovered	Ibid.
365	Marsil	1877	Machinery laceration and fracture	Primary. Post. flap	Recovered	L'Union Méd. du Canada, 1878, p. 9.
366	Mason	1876	Atrophy and paralysis of lower extremity	Circular	Recovered	N. Y. Med. Journ., 1876, xxiv. 561–585.
367	do.	1876	Malignant tumor of thigh. Unsuccessful attempt at removal	Circular	Recovered	Ibid.
368	do.	1877	Coxalgia. Gangrene of foot	Circular	Recovered	Ibid., 1878, xxvii. 146–153.
369	Mauger	1855	Gunshot fracture of femur	Intermediate	Died	Otis, No. 13, p. 61.
370	Maury	1869	Malignant disease of thigh	Ant.-post. flaps	Died. Return of disease in stump and viscera	Phila. Med. Times, 1870, i. 71.
371	May	1850	Scrofulous degeneration of femur	Béclard's method	Recovered	Am. Journ. Med. Sci., 1851, xxii. 313.
372	Mayo	....	Neuroma	Reamputation	Recovered	Lancet, 1836–37, i. 110.
373	McDougall	1860	Pistol wound of femur	Intermediate	Recovered	Circ. No. 2, S. G. O., p. 110.
374	McGraw	1872	Tumor of thigh. Extirpated 5 times	Lateral flaps	Recovered	Detroit Rev. Med. and Pharm., 1872, vii. 466.
375	McGuire	....	Gunshot injury of femur	Primary	Died	Circ. No. 2, S. G. O., p. 108.
376	McKee	1864	Gunshot fracture of femur	Secondary. Ant.-post. flaps	Died, 1 hour	Otis, No. 12, p. 64.
377	McKenzie	1854	Gunshot fracture of femur	Primary	Died within 24 hours	Ibid., No. 16, p. 56.

CASES OF HIP-JOINT AMPUTATION.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
378	McLean	1862	Comminution of neck and trochanters of femur by fragment of shell	Primary. Lateral flaps	Died, 2 hours	Otis, No. 26, p. 57.
379	Merck	1853	Caries following complicated fracture	Secondary. Int. flap	Recovered	Lüning, No. 155.
380	Morton	1879	Spindle-celled sarcoma of femur	....	Died, 3d day	Glasgow Med. Journ., 1880, xiii. 61.
381	Morton, T. G.	1866	Osteo-myelitis after thigh amputation for gunshot injury	Reamputation. Ant.-post. flaps	Recovered	Surgery in Penna. Hospital, Phila., 1880, p. 34.
382	do.	1877	Osteo-myelitis	Reamputation. Modified circular	Recovered	Ibid.
383	do.	1878	Osteo-myelitis	Reamputation. Modified circular	Recovered	Ibid.
384	do.	1879	Osteo-enchondroma	Modified circular	Died	Ibid.
385	Mott	1824	Caries following fracture	....	Recovered	Phila. Journ. Med. and Phys. Sci., vol. v.
386	Mott, A. B.	1864	Necrosis after thigh amputation for bayonet wound	Reamputation. Ant.-post. flaps	Recovered	Otis, No. 8, p. 65.
387	Mounier	1854	Gunshot fracture of femur	Intermediate	Died, 2 days	Ibid., No. 8, p. 60.
388	do.	1854	Gunshot fracture of femur	Intermediate	Died, 1 week	Ibid., No. 10, p. 60.
389	do.	1855	Gunshot fracture of femur	Intermediate	Died	Ibid., No. 11, p. 61.
390	Mulder	1798	....	....	Recovered	Velpeau, op. cit., t. ii. p. 539.
391	Mundy	1871	Gunshot fracture of thigh. Gangrene	Intermediate (?)	Died, 12 hours	Langenbeck, op. cit.
392	Murbach	1877	Coxalgia. Previous excision	Circular	Recovered	N. Y. Med. Record, 1877, p. 650.
393	Murfree	1872	Malignant disease of femur	Ant.-post. flaps	Recovered	Am. Journ. Med. Sci., 1875, lxix. 289.
394	Murphy	1878	Encephaloid following injury	....	Recovered	Med. and Surg. Reporter, Phila., 1878, xxxix. 188.
395	Nancrede	1881	Alveolar osteo-sarcoma of femur	Ant.-post. flaps	Died, 11th day	Phila. Med. Times, 1881, xi. 472.
396	Nélaton	1848	Chronic disease	....	Recovered. Died, 4 months later from pneumonia	Lancet, 1857, i. 6.
397	Neudörfer	1859	Gunshot fracture of femur	Secondary	Recovered	Otis, No. 10, p. 64.
398	Neumann, Sr.	1864	Crush of thigh	Intermediate. Post. flap	Died, 4 days	Lüning, No. 313.
399	Neumann, Jr.	1867	Myxo-sarcoma of left thigh	Oval	Died, 6 days	Ibid., No. 388.
400	Newitt and Whitla	1875	Necrosis of femur. Spontaneous fracture	Ant.-post. flaps	Recovered	Dublin Journ. Med. Sci., 1877, lxiv. 443.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
401	O'Grady	1874	Reamputation for osteo-myelitis after thigh amputation	Reamputation. Ant.-post. flaps	Recovered	Dublin Journ. Med. Sci., 1876, lxi. 78.
402	do.	1874	Necrosis of femur	Flap operation	Died, 35 hours	Ibid.
403	Orlowski	1879	Osteo-myelitis	Circular	Recovered	Rev. des Sci. Méd., Paris, 1880, xvi. 279.
404	Orton	1824	Caries. Spontaneous fracture	Single flap	Recovered	Med.-Chir. Trans., Lond., xiii. 605.
405	Otis	1870	Gunshot wound of leg. Amputation. Reamputation through knee-joint. Amputation at hip-joint	Reamputation. Ant.-post. flaps	Recovered	Am. Journ. Med. Sci., 1871, lxi. 141–149.
406	Ott	1870	Gunshot wound of femur	Intermediate. Ant. flap	Died in a few hours	Langenbeck, op cit.
407	Packard	1865	Necrosis after thigh amputation for gunshot fracture	Reamputation. Ant.-post. flaps	Recovered	Otis, No. 4, p. 65.
408	Pancoast	1860	Medullary sarcoma	Modified circular	Recovered. Died in 2 years from return of disease in trunk	Surgery in Penna. Hospital, Phila., 1880, p. 34.
409	do.	1865	Osteo-chondroma	Modified circular	Recovered	Am. Journ. Med. Sci., lii. 28.
410	Parker	1874	Coxalgia. Previous excision	Ant.-post. flaps	Recovered	Lancet, 1875, ii. 699.
411	do.	....	....	....	Died	Br. Med. Journ., 1880, i. 697.
412	Patterson	1879	Extensive necrosis. Spontaneous fracture	Ant.-post. flaps	Died, 10 hours	Glasgow Med. Journ., 1879, N. S., xi. 90–92.
413	Paulet	1855	Gunshot fracture of femur	Primary	Died, 1 hour	Otis, No. 18, p. 56.
414	Pauli	1823	Aneurism. Gangrene	....	Died, 5 days	Lüning, No. 42.
415	Peachy	1861	Gunshot fracture of femur. Gangrene	Intermediate. Larrey's method	Died, 2 days	Otis, No. 17, p. 61.
416	Pelikan	1820	Tumor of femur	Larrey's method	Died, 2 months	Lüning, No. 32.
417	do.	1820	Fungus hæmatodes	Larrey's method	Died, 8 weeks	Ibid., No. 33; Lancet, 1853, ii. 406.
418	Pelletan	....	....	....	Died	Cooper, op. cit., vol. i. p. 117.
419	Perault	1773	Crush of thigh. Nearly disarticulated by gangrene and sloughing	Secondary	Recovered	Smith, loc. cit., p. 192.
420	Perret	1798	Gunshot fracture of thigh	....	Recovered	Velpeau, op. cit., ii. 539.
421	Perrin	1855	Gunshot fracture of leg and thigh	Primary	Died, 1 or 2 days	Otis, No. 22, p. 57.
422	Petechin	1865	Suppurative periostitis and osteo-myelitis of femur	Modified circular	Recovered	Arch. klin. Chir., Berlin, 1868, ix. 250.
423	Pineo	1862	Trochanter perforated by a musket ball	Intermediate	Died, 3 hours	Otis, No. 24, p. 62.

CASES OF HIP-JOINT AMPUTATION.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
424	Pirogoff	1854–55	(In the Russian Army)	Primary	Died, 5 days	Circ. No. 7, S. G. O., 1867, p. 14.
425	do.	1854–55	(In the Russian Army)	Primary	Died, 5 days	Ibid.
426	do.	1854–55	(In the Russian Army)	Primary	Died, 2 or 3 days	Ibid.
427	do.	1854–55	(In the Russian Army)	Primary	Died, 2 or 3 days	Ibid.
428	do.	1854–55	(In the Russian Army)	Primary	Died	Ibid.
429	do.	1854–55	(In the Russian Army)	Primary	Died, 2 or 3 days	Ibid.
430	do.	1854–55	(In the Russian Army)	Primary	Died, 2 or 3 days	Ibid.
431	do.	1854–55	(In the Russian Army)	Primary	Died, 2 or 3 days	Ibid.
432	Pollock	1872	Encephaloid of femur	Ant.-post. flaps	Recovered	Lancet, 1873, i. 696.
433	do.	1873	Mixed tumor of femur	Ant.-post. flaps	Died from secondary deposits in lungs	Ibid., p. 839.
434	Poncet	1880	Sarcoma of femur	....	Undetermined	Rev. des Sci. Méd., Paris, 1880, xvi. 278.
435	Porcienko	1821	Necrosis of femur with abscesses	Lateral flaps	Died, 12th day	Smith, loc. cit., p. 194.
436	do.	1834	....	....	Died	Lüning, No. 78.
437	Potter	1860	Disease of femur following kick by a horse	....	Recovered	Circ. No. 7, S. G. O., p. 18.
438	do.	1853	Caries from injury	....	Recovered	Eve, op. cit., p. 564.
439	Potts	1861	Gunshot fracture of femur	Intermediate Ant.-post. flaps	Died, 10 hours	Otis, No. 19, p. 61.
440	Poupart	1862	Complicated fracture of right thigh	Intermediate. Ant. flap	Recovered	Bull. de l'Acad. de Méd. de Belg., 2me s., vi. 447.
441	Powell	1871	Cancerous ulceration of thigh stump one year after amputation	Reamputation. Ant.-post. flaps	Doing well 4 days later	Chicago Med. Journ., 1871, xxviii. 103.
442	Prat	1856	Caries	....	Died	Lüning, No. 225.
443	Quarrier	1816	Gunshot wound of thigh and femur	Primary. Larrey's method	Died immediately	Med.-Chir. Trans., viii. pt. 1, p. 4.
444	Raynaud	1870	Gunshot injury. (Franco-Prussian War)	Primary (?)	Died during operation	Bull. de l'Acad. de Méd., Paris, 2me s., vi. 1141.
445	Restelli	1848	(After the insurrection in Lombardy)	Intermediate	Recovered	Circ. No. 2, S. G. O., p. 110.
446	Reverdin	....	Tumor of femur	....	Died	Index Medicus, July, 1881, p. 318.
447	Richardson	1879	Coxalgia	....	Recovered	Br. Med. Journ., 1879, ii. 606.
448	Richet	1848	(Injury at insurrection in Paris)	Primary. Ant.-post. flaps	Died	Bull. de l'Acad. de Méd., Paris, 2me s., vii. 35.
449	do.	1850	Diffuse suppurating periostitis of femur	Modified flap operation	Recovered	Ibid., p. 38.
450	do.	1864	Large osteo-sarcoma of femur	Ant.-post. flaps	Recovered. Died, 1 year later	Ibid., p. 43.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
451	Ried	1866	Sarcoma of thigh	Oval	Recovered	Lüning, No. 375.
452	Rivington	1876	Coxalgia	Ant.-post. flaps	Recovered	Lancet, 1877, i. 419.
453	do.	1877	Coxalgia	....	Died, 2 days	Ibid., ii. 124.
454	Robert	1848	Gunshot injury in Paris insurrection	Intermediate	Died	Circ. No. 7, S. G. O., p. 13.
455	Roberts	1864	Gunshot fracture of femur	Intermediate. Ant.-post. flaps	Died, 4 days	Otis, No. 31, p. 62.
456	Rohrer	1863	Gunshot wound of thigh and hip	Intermediate. Ant.-post. flaps	Died, 36 hours	Am. Journ. Med. Sci., 1869, lvii. 285.
457	Rose	1869	Crush of both thighs	Primary. Ant.-post. flaps	Died	Lüning, No. 407; Bull. de l'Acad. de Méd. 2me s., vi. 1141.
458	do.	1872	Sarcoma of thigh	Flap operation	Recovered	Ibid.
459	do.	1875	Sarcoma of thigh	Post. flap	Recovered	Ibid.; Lüning, No. 495.
460	Roser	1857	Necrosis after thigh amputation	Reamputation	Recovered	Ibid., No. 233.
461	Roux, P. J.	1830	Gunshot fracture of great trochanter	Primary. Lateral flaps	Died on day of operation	Otis, No. 6, p. 55.
462	Roux, Jules	1848	Diffuse suppuration of thigh	Flap operation	Died, 15 days	Lüning, No. 118.
463	do.	1859	Chronic osteo-myelitis following injury	Reamputation. Flap operation	Recovered	Ibid., No. 251.
464	do.	1859	Fracture of femur by fall from a mast	Primary. Flap operation	Died, 5 hours	Ibid., No. 250.
465	do.	1859	Gunshot fracture of femur	Secondary. Ant.-post. flaps	Recovered	De l'Ostéomyélite, Paris, 1860, Obs. xxvii.
466	Rüppel	1870	Gunshot wound of thigh	....	Died soon after	Langenbeck, op. cit.
467	Rusk	1880	Diffused femoral aneurism	Ant.-post. flaps	Recovered	Med. and Surg. Reporter, Phila., 1880, xliii. 400.
468	Salleron	1855	Gunshot fracture of femur	Intermediate. Oval	Died, 20 hours	Otis, No. 14, p. 61.
469	do.	1855	Gunshot fracture of femur	Intermediate. Oval	Died, 60 hours	Ibid., No. 15, p. 61.
470	Sands	1869	Railway crush of left thigh	Primary. Ant.-post. flaps	Recovered	N. Y. Med. Record, 1871, vi. 11.
471	Santee	1876	Tumor of thigh	....	Died	Register of Episcopal Hospital, Phila.
472	Savory	1873	Osteo-sarcoma of stump	Reamputation. Ant.-post. flaps	Died. Secondary deposits	Lancet, 1873, ii. 229; Tr. Path. Soc., 1874, xxv. 210.
473	do.	....	Malignant tumor of femur	....	Undetermined	Br. Med. Journ., 1877, ii. 665.
474	Scotti	1859	(Italian war)	Intermediate	Died	Circ. No. 2, S. G. O., p. 109.
475	Scoutetten	1835	....	....	Undetermined	Lüning, No. 81.
476	Secourgeon	1861	Coxalgia	Oval	Died, 2 months	Jamain et Wahu Ann., 1862, p. 221.
477	Sédillot	1831	Gunshot fracture of neck of right femur	Primary. Oval method	Died shortly afterwards	Otis, No. 7, p. 55.

CASES OF HIP-JOINT AMPUTATION.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
478	Sédillot	1840	Compound comminuted fracture of thigh	Secondary. Single ant. flap	Recovered	Smith, loc. cit.
479	Shippen	1863	Gunshot fracture of femur	Primary. Ant. flap	Recovered	Otis, No. 34, p. 58.
480	do.	1864	Gunshot fracture of femur	Primary. Ant. flap	Died, 1 hour	Ibid., No. 42, p. 59.
481	do.	1864	Gunshot fracture of head and neck of femur	Intermediate. Single ant.-int. flap	Died, 1 hour	Ibid., No. 29, p. 62.
482	Simon	1870	Gunshot fracture of femur	Intermediate	Died, 3 days	Langenbeck, op. cit.; Lüning, No. 428.
483	Smith	1835	Compound fracture of femur	Primary. Ant.-int. and post.-ext. flaps	Died	Med. Gazette, London, xvi. 551.
484	Smith, D. P.	1862	Gunshot fracture of femur	Intermediate. Ant. flap	Died, 8 days	Otis, No. 20, p. 61.
485	Smyth	1878	Disease of upper femur. Previous excision of hip-joint	....	Recovered	Br. Med. Journ., 1879, i. 227.
486	Spence	1862	Malignant tumor of thigh	Ant.-post. flaps	Recovered	Edin. Med. Journ., 1863, viii. 585.
487	do.	1865	Tumor of femur	Ant.-post. flaps	Recovered	Ibid., 1865, xi. 396.
488	do.	1875	Necrosis of femur and fibula	Ant.-post. flaps	Recovered	Lancet, 1875, ii. 591.
489	do.	1875	Coxalgia. Previous excision	Ant.-post. flaps	Recovered	Ibid.
490	do.	....	Tumor of thigh	....	Died	Lectures on Surgery, ii. 763.
491	do.	....	Tumor of thigh	....	Died	Edin. Med. Journ., Nov. 1879.
492	do.	....	Chronic disease	....	Died	Spence, op. cit.
493	do.	....	Traumatic	Primary	Recovered	Ibid.
494	do.	....	Traumatic	Primary	Died	Ibid.
495	do.	....	Traumatic	Primary	Died	Ibid.
496	do.	....	Traumatic	Primary	Died	Ibid.
497	do.	....	Traumatic	Primary	Died	Ibid.
498	Sper	1825	Gunshot fracture of femur	....	Died	Lüning, No. 53.
499	Stanley	1857	Medullary cancer of femur	Ant.-post. flaps	Died, 2 hours	Lancet, 1857, i. 343, 380.
500	Steiner	1846	Gunshot injury of femur	Primary	Died of shock	Circ. No. 2, S. G. O., p. 110.
501	Stokes	1879	Coxalgia. Caries and necrosis	Ant.-ext. and post.-int. flaps	Recovered	Br. Med. Journ., 1880, i. 697.
502	Stout	1859	Coxalgia	Ant.-post. flaps	Recovered. Died in 1 year from epilepsy	Pacific Med. and Surg. Journ., 1862, v. 267.
503	Swain	....	Coxalgia. Previous excision	....	Undetermined	Lancet, 1879, i. 405.
504	do.	1864	Encephaloid of thigh	Ant.-post. flaps	Died in less than 24 hours	Ibid., 1865, i. 567.
505	Sweat	1844	Osteo-myelitis	Reamputation. Circular	Recovered	N. Y. Journ. Med., 1847, ix. 38.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
506	Syme	1848	Necrosis following thigh amputation	Reamputation	Recovered	Edin. and London Monthly Journ., 1848.
507	do.	....	....	....	Died	Fergusson's Surg., 4th ed., p. 506.
508	do.	....	....	....	Died	Ibid.
509	do.	1866	Medullary sarcoma	....	Died, 8 days	Lüning, No. 377.
510	Tassani	1859	(Italian war)	Intermediate	Died	Circ. No. 2, S. G. O., p. 109.
511	Tatum	1855	Encephaloid of femur	Ant.-post. flaps	Recovered	Lancet, 1855, ii. 77.
512	Tay	1873	Coxalgia	Ant.-post. flaps	Recovered	Br. Med. Journ., 1873, ii. 461.
513	Teale	1869	Encephaloid	Ant.-post. flaps	Stump healed. Died of cancer in lungs	Ibid., 1870, ii. 88.
514	do.	1871	Coxalgia. Previous excision	Flap operation	Recovered	Med. Times and Gaz., Lond., 1873, ii. 93.
515	do.	1873	Malignant disease following injury	Flap operation	Recovered	Ibid.
516	Textor, Sr.	1841	Gangrene of stump following knee-joint amputation	Reamputation	Recovered	Smith, loc. cit.; Lüning, No. 98.
517	do.	1842	Profuse suppuration with necrosis	....	Died, 13 days	Ibid., No. 101.
518	do.	1847	Caries and necrosis	Flap operation	Recovered	Ibid., No. 116.
519	do.	1849	Caries of great trochanter	....	Recovered	Ibid., No. 141.
520	Textor, Jr.	1848	Gunshot fracture	Intermediate	Died, 4 days	Ibid., No. 126.
521	do.	1851	Necrosis after thigh amputation	Reamputation	Died, 11 days	Ibid., No. 146.
522	do.	1851	Periostitis and necrosis of femur	....	Died, 7 days	Ibid., No. 147.
523	Thebaud	1858	Caries	Flap operation	Died, 12th day	N. Y. Med. Press, 1860, iii. 33.
524	Thomas	1855	Gunshot fracture of femur	Primary	Died, 5 hours	Otis, No. 20, p. 57.
525	do.	1855	Gunshot fracture of femur	Primary	Died, 11 hours	Ibid., No. 21, p. 57.
526	Thomson, H.	....	Coxalgia	....	Died	Dr. John Thomson, Report on Belg. Hosps., Edin., 1816, p. 264.
527	Thomson, J.	1864	Malignant disease	....	Recovered	Lüning, No. 315.
528	Thorn	....	Caries of femur	Ant.-post. flaps	Died in a few hours	Toledo Med. and Surg. Journ., 1878, ii. 217.
529	Tillaux	1878	Osteo-sarcoma following fracture of femur	Galvano-cautery	Died, 48 hours	Gaz. Méd. de Paris, 1878, p. 87.
530	Townsend	1869	Disease of femur following fracture of leg	Ant.-post. flaps	Recovered	N. Y. Med. Record, 1870, v. 415.
531	Townshend	1871	Punctured wound of femur. Diffuse suppurating periostitis	Intermediate. Double flap	Recovered	Am. Journ. Med. Sci., 1877, lxxviii. 385.
532	Trèlat	1878	Necrosis of femur	Ant. flap	Recovered	Bull. de l'Acad. de Méd., Paris, 1872, p. 76.
533	Trezzi	1848	Gunshot injury	Intermediate	Died	Circ. No. 2, S. G. O., p. 110.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
534	Trousdell	1855	Comminution of upper thigh by a cannon ball	Primary. Double flaps	Died within 24 hours	Otis, No. 25, p. 57.
535	Tyler	1867	Osteo-myelitis after thigh amputation for injury	Reamputation	Recovered	Med. Times and Gaz., 1868, ii. 697.
536	do.	1869	Comminuted fracture. Osteo-myelitis	Intermediate	Died, 4 days	Ibid., 1870, ii. 118.
537	do.	1869	Tumor of thigh	Single ant. flap	Recovered	Ibid.
538	Uhde	1851	Crush of right thigh	Flap operation	Died. 12 hours	Lüning, No. 148.
539	do.	1868	Railway crush	Primary	Recovered	Arch. klin. Chir., Berlin, 1876, xx. 636.
540	Unknown	1798	At Abukir. Gunshot injury	....	Recovered	Lüning, No. 5.
541	do. (In Spain)	....	....	....	Died	Ibid., No. 25.
542	do. do.	....	....	....	Recovered	Ibid., No. 26.
543	do. (Algiers)	1836–40	....	Primary	Died	Ibid., No. 88.
544	do. do.	1836–40	....	Primary	Died	Ibid., No. 89.
545	do. do.	1836–40	....	Primary	Died	Ibid., No. 90.
546	do. (Vienna)	1848	Gunshot wound	....	Died	Ibid., No. 125.
547	do. (Schleswig Holstein)	1848	....	....	Died	Ibid., No. 131.
548	do. do.	1849	....	....	Died	Ibid., No. 132.
549	do. do.	1849	....	....	Died	Ibid., No. 133.
550	do. (Punjaub)	1848–49	Gunshot fracture	Primary	Died, 6 hours. Shock	Ibid., No. 137.
551	do. do.	1848–49	Gunshot fracture	Primary	Died, 12 hours	Ibid., No. 138.
552	do. do.	1848–49	Gunshot fracture	Primary	Died, 36 hours	Ibid., No. 139.
553	do. (Crimea)	1854–55	(Soldier in Sardinian Army)	....	Died	Circ. No. 7, S. G. O., p. 14.
554	do. do.	1854–55	(Soldier in Sardinian Army)	....	Died	Ibid.
555	do. do.	1854–55	(English soldier)	Primary	Died	Ibid.
556	do. do.	1854–55	(English soldier)	Primary	Died	Ibid.
557	do. do.	1854–55	(English soldier)	Primary	Died	Ibid.
558	do. do.	1854–55	(English soldier)	Primary	Died	Ibid.
559	do. do.	1854–55	(English soldier)	Primary	Died	Ibid.
560	do. do.	1854–55	(English soldier)	Primary	Died	Ibid.
561	do. do.	1854–55	(French soldier)	Primary	Died	Lüning, No. 204.
562	do. do.	1854–55	(French soldier)	Primary	Died	Ibid., No. 205.
563	do. do.	1854–55	(French soldier)	Primary	Died	Ibid., No. 206.
564	do. do.	1854–55	(French soldier)	Primary	Died	Ibid., No. 207.
565	do. do.	1854–55	(French soldier)	Primary	Died	Ibid., No. 208.
566	do. do.	1854–55	(French soldier)	Primary	Died	Ibid., No. 209.
567	do. do.	1854–55	(French soldier)	Primary	Died	Ibid., No. 210.

Cases of Hip-joint Amputation.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
568	Unknown (In Italy)	1859	....	Secondary	Recovered	Circular No. 2, S. G. O., p. 109.
569	do. (In Dresden)	1866	Gunshot fracture	... .	Died	Lüning, No. 374.
570	do. (Franco-Prussian)	1870	....	... .	Died	Ibid., No. 430.
571	do. do.	1870	....	....	Died	Ibid., No. 431.
572	do. do.	1870	....	....	Died	Ibid., No. 432.
573	do. do.	1870	....	....	Died	Ibid., No. 433.
574	do. do.	1870	(French soldier)	....	Died	Ibid., No. 442.
575	do. do.	1870	(French soldier)	....	Died	Ibid., No. 443.
576	do. do.	1870	(French soldier)	....	Died	Ibid., No. 444.
577	do. do.	1870	(French soldier)	....	Died	Ibid., No. 445.
578	do. do.	1870	(French soldier)	....	Died	Ibid., No. 446.
579	do. do.	1870	(French soldier)	....	Died	Ibid., No. 447.
580	do. do.	1870	(French soldier)	....	Died	Ibid., No. 448.
581	do. do.	1870	(French soldier)	....	Died	Ibid., No. 449.
582	do. do.	1870	(French soldier)	....	Died	Ibid., No. 450.
583	do. do.	1870	(French soldier)	....	Died	Ibid., No. 451.
584	do. do.	1870	(French soldier)	....	Died	Ibid., No. 452.
585	do. do.	1870	(French soldier)	....	Died	Ibid., No. 453.
586	do. do.	1870	(French soldier)	....	Died	Ibid., No. 454.
587	Van Buren	1850	Osteo-chondroma	Reamputation. Flap operation	Recovered	Tr. N. Y. Acad. of Med. 1847–57, vol. i. p. 124.
588	do.	1853	Railroad accident	....	Died	Circ. No. 7, S. G. O., p. 18.
589	do.	1855	Railroad accident	....	Died	Ibid., p. 18.
590	Varick	1874	Compound comminuted fracture of thigh. Railroad accident	Primary	Died, 2 days	Am. Journ. Med. Sci., n. s., clxii. 435.
591	do.	1877	Compound comminuted fracture of thigh. Railroad accident	Primary	Died	Ibid., p. 437.
592	Velpeau	1831	Strumous disease of thigh following injuries	Ant.-post. flaps	Died, 14th day	Velpeau, op. cit., t. ii. p. 541.
593	do.	....	....	....	Died, 3d day	Ibid.
594	Verneuil	1864	Myeloid tumor of thigh	Ant.-post. flaps	Died, 29 days	Bull. de l'Acad. de Médecine, 1877.
595	do.	1868	Osteo-myelitis of femur. Spontaneous fracture	Flap	Died, 2 hours	Ibid.
596	do.	1869	Fibro-colloid tumor of thigh	Flap	Died, 24 days	Ibid.
597	do.	1877	Fibro-colloid tumor of thigh	Author's method	Recovered	Ibid.

CASES OF HIP-JOINT AMPUTATION.—*Continued.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
598 *	Vidal (de Cassis)	1848	Gunshot fracture of femur. Profuse suppuration and great constitutional irritation	Intermediate. Single ant. flap	Died	Otis, No. 6, p. 60.
599	Volkmann	1867	Complicated fracture	Intermediate	Recovered	Lüning, No. 389.
600	do.	1868	....	Reamputation	Died, 4 weeks	Ibid., No. 399.
601	do.	1868	Fracture of leg. Gangrene	Intermediate. Large ant. flap	Died, 4 days	Ibid., No. 400; Hug. Obs. 23.
602	do.	1873	Railway injury	Circular	Died	Lüning, No. 476.
603	do.	1873	Suppuration of hip-joint	Circular	Recovered	Ibid., No. 477.
604	do.	1873	Tumor of thigh	Flap operation	Died	Ibid., No. 478.
605	Von Walther	1824	Tumor of femur. Fracture	Lateral flaps	Died, 11th day	Smith, loc. cit.
606	Wagner	1864	Partial fracture of femur, by musket ball	Secondary. Ant.-post. flaps	Died, 29 hours	Otis, No. 13, p. 64.
607	Warren, Edward	1861	Gunshot fracture of femur	Intermediate. Double flaps	Died, 30 hours	Ibid., No. 18, p. 61.
608	Warren, J. Mason	1859	Osteo-sarcoma	....	Recovered	Boston Med. and Surg. Journ., 1872, ix., Appendix, p. vi.
609	do.	1858	Compound fracture	....	Died	Ibid.
610	Watson	1866	Malignant disease of femur	Ant.-post. flaps	Died from cancer in lungs	Brit. Med. Journ., 1868, ii. 242–244.
611	Wedemeyer	1821 (?)	....	....	Recovered	Velpeau, op. cit., t. ii. p. 540.
612	do.	....	Gunshot injury	Intermediate	Died	Legouest, op. cit.
613	do.	....	Gunshot injury	Secondary	Died	Ibid.
614	Weir	1864	Gunshot fracture of femur	Secondary. Ant.-post. flaps	Died, 4 months after	Otis, No. 14, p. 64.
615	Wells	1862	Malignant tumor of thigh. (Encephaloid)	....	Lived nearly a year. Died of cancer	Lancet, 1865, i. 652; Dublin Journ. Med. Sci., 1866, xlii. 303.
616	Welz	1832	....	... .	Died	Lüning, No. 70.
617	West	1879	Epithelioma of thigh. Amputation. Return of disease	Reamputation. Jordan's method	Recovered	Lancet, 1879, ii. 506.
618	do.	1878	Malignant tumor of femur	Oval method	Died from shock	Ibid., 1878, ii.
619	Westmoreland	....	Gunshot injury	.... ..	Undetermined	Circ. No. 2, S. G. O., p. 109.
620	Wheatcroft	....	Coxalgia. Spontaneous fracture	Three flaps	Died, 4 hours	Lancet, 1853, i. 470.
621	Whipple	1846	Extensive disease of knee and thigh	Ant.-post. flaps	Recovered	Ibid., 1846, i. 683.
622	Whitcomb	1866	Disease of femur after thigh amputation for gunshot injury	Reamputation. Ant.-int. flap	Died, 5 hours	Otis, No. 7, p. 65.
623	Whitehead	1879	Coxalgia. Previous excision. Amputation for secondary hemorrhage	....	Died on the table	Br. Med. Journ., 1879, ii. 693.

Cases of Hip-joint Amputation.—*Concluded.*

No.	Operator.	Date.	Nature of Case.	Period and Form of Operation.	Result.	Authority.
624	Wigstrom	1850	Caries of leg, knee, and femur	Ant.-post. flaps	Recovered	Lancet, 1850, i. 411.
625	Wilde	1866	....	Intermediate	Died	Circ. No. 2, S. G. O., p. 111.
626	Wilms	1855–56	Crush of thigh	Oval method	Died, 19 hours	Lüning, No. 223.
627	Wishart	1864	Gunshot injury of thigh and femur	Primary. Ant.-post. flaps	Died in a few hours	Circ. No. 2, S. G. O., 1869, p. 108.
628	Wright	1867	Hospital gangrene, and necrosis of femur following gunshot wound	Secondary. Guthrie's method	Alive one year after	Cincinnati Lancet and Obs., 1868, n. s., xi. 257; Circ. No. 2, S. G. O., p. 109.
629	Wyatt	1854	Gunshot fracture of thigh. Several bayonet wounds	Primary	Died immediately	Otis, No. 17, p. 56.
630	Yandell	1862	Gunshot fracture of femur	Primary	Died, 7 hours	Ibid., No. 27, p. 57.
631	Young, E. P.	1862	Railway crush of both lower limbs. Double amputation of thigh and hip	Primary	Died in a few hours from shock	Lancet, 1865, i. 652.
632	Young (of Sevenoaks)	1879	Coxalgia	....	Recovered	Br. Med. Journ., 1879, ii. 686.
633	Zeis	1857	Tumor of thigh	....	Died, $\frac{1}{2}$ hour	Lüning, No. 234; Arch. klin. Chir., vii. 760.

Note.—The cases referred by number to Otis, Lüning, and Hug, are taken from, "A Report on Amputations at the Hip-joint in Military Surgery," Circular No. 7, War Department, Surgeon-General's Office, Washington, 1867; "Über die Blutung bei der Exarticulation des Oberschenkels und deren Vermeidung," Inaugural-Dissertation von August Lüning, Med. pr., Zurich, 1876; and "Des Causes de la Mort à la Suite de la Désarticulation Coxo-Fémorale," Thèse par Alfred Hug, Paris, 1877.

A number of cases of Hip-joint Amputation are noted in the reports of the various London hospitals, but only such have been included in the above Table as were sufficiently detailed for the purpose.

The following references from the Index-Catalogue of the Library of the Surgeon-General's Office, I have not been able to verify: Brochin, Gazette des hôpitaux, Paris, 1877; Carpio, Gaceta médica de México, 1865; Carrasco, Génio médico-quirúrgico, Madrid, 1875; De Villagran, Gaceta médica de México, 1865; Garbi, Gazzetta medica Italiana, Provincie Venete, Padova, 1875; Hawerkamp, "Ein Fall von Exarticulatio Femoris," Berlin, 1878; Köhler, Charité-Annalen, Berlin, 1879; Lesi, Raccoglitore medico, Forli, 1878; Männel, Allgemeine Wiener medizinische Zeitung, 1867; Moroni, Giornale Veneto di scienze mediche, Venezia, 1870; Partridge, Indian Medical Gazette, Calcutta, 1868; Peterson, Berliner klinische Wochenschrift, 1872; Rota, Annali universali di medicina, Milano, 1866, 1869; Sick, Journal der Chirurgie und Augen-Heilkunde, Berlin, 1829; Silvestri, Lo Sperimentale, Firenze, 1871; Tansini, Gazzetta medica Italiana Lombardia, Milano, 1854; Tirifahy, Presse médicale Belge, Bruxelles, 1878; Ustariz y Escribano, Revista de medicina y cirugia prácticas, Madrid, 1872.

F. C. S.

INDEX.

VOL. I.

ABSCESS, 117
Accidents of anæsthesia, 412, 415
Acetic ether, 432
Acid, carbolic, 430
Actual cautery, 504
Acupuncture, 502
Administration of anæsthetics, 412
  of chloroform, 446
  of ether, 443
Age, effect of, in amputation, 618
    in anæsthesia, 414
    in operations, 459
    in shock, 359
  in surgical diagnosis, 339
AGNEW, surgical diagnosis, 337
Air in veins after operations, 476
  dressing of stump, 594
  passages, effect of anæsthetics on, 406
    erysipelas of, 201
Alcohol in erysipelas, 198
Alcoholism, 322
Alcohols, 430
Aldehydes, 432
Allen's method of transfusion, 512
Ammonia in shock, 373
Amputation or amputations, 551
  advantages of different methods, 589
  at ankle, 656
  of arm, 642
  for avulsion of limb, 559
  Carden's, 665
  cases of, 612
  Chopart's, 653
  circular operation, 579
      history of, 556
  for compound fractures and luxations, 560
  conditions calling for, 559 *et seq.*
  for deformities, 564
  for disease of bones and joints, 564
  for dry gangrene, 563
  effect of age in, 618
    of constitutional condition, 622
Amputation—
  for effects of heat and cold, 562
  effect of hygienic surroundings on, 623
    of nature of lesion on, 625
    of part involved on, 629
    of period of, 627
    of sex on, 622
  at elbow, 640
  elliptical operation, 583
  erysipelas in, 624
  of fingers, 631 *et seq.*
  flap operation in, 558
      double, 585
      single, 584
  of foot, 650
  of forearm, 639
  Gritti's, 665
  for gunshot injuries, 561
  Hancock's, 655
  of hand, 634
  Hey's, 652
  at hip-joint, 669
  history of, 552 *et seq.*
  for hospital gangrene, 563
  instruments for, 565
  at knee, 663, 665
  at knee-joint, 663
  for lacerated and contused wounds, 560
  Langenbeck's method, 587
  Lee's, 662
  Le Fort's, 659
  of leg, 660
  for lesion of arteries, 562
  ligature in, 554
  Lisfranc's, 652
  Lister's method, 588
  Malgaigne's method, 584
  at medio-tarsal joint, 653
  at metacarpus, 635, 636
  at metatarsus, 650 *et seq.*
  modified circular operation, 582
  for morbid growths, 564

Amputation—
mortality and causes of death after, 610
for mortification, 562
operative methods employed in, 579 *et seq.*
oval operation, 584
Pirogoff's, 658
pyæmia in, 624
Ravaton's method, 585
Roux's, 658
Scoutetten's method, 584
Sédillot's method, 586, 661
above shoulder, 647
at shoulder, 643
simultaneous, 590
special, of lower extremity, 649 *et seq.*
of upper extremity, 631 *et seq.*
Stokes's, 666
subastragaloid, 654
Syme's 656
synchronous, 590, 592
Teale's method, 587
for tetanus, 564
of thigh, 667
of thumb, 634
of toes, 649
tourniquet in, 553
Tripier's, 655
Vermale's method, 585
at wrist, 637
Amyl chloride, 429
iodide, 429
nitrite, 429
Amylene, 425
Amyloid degeneration, 62
Anæmia, 3
Anæsthesia, 403. See also Anæsthetics.
accidents of, 412, 415
after-treatment of, 445
artificial, mortality from, 422
asphyxia during, 412
from compression, 422
in dentistry, 417
by electricity, 419
history of, 403
influence of age, sex, and temperament on, 414
of cerebral and spinal diseases on, 414
of excitement or terror on, 415
of intra-thoracic diseases on, 415
of rate of inhalation on, 414
from intravenous injections, 419
local, 418, 447
meaning of, 403
in obstetrics, 416
in operations, 441
phenomena of, 406
physiology of, 409
Anæsthesia—
post-mortem appearances after death from, 423
by rapid respiration, 419
in surgery, 416
syncope during, 412
by various methods, 419, 448
Anæsthetic mixtures, 420
substances, 424
Anæsthetics, 403
administration of, 412
effect of, on action of heart, 408
on air passages, 406
on brain, 407
on eyes, 406
on general sensibility, 406
on muscular movements, 407
on nervous centres, 414
on power of volition, 407
on reflex action, 408
on respiration, 408
on secretions, 408
on temperature, 408
employment of, 416
in shock, 374
Aneurism of aorta, 329
of stumps, 604
Ankle, amputation of, 656 *et seq.*
Anodynes in inflammation, 156
Antecedent history in surgical diagnosis, 341
Antiseptic dressing of stumps, 597
Antiseptics in inflammation, 159
Aorta, aneurism of, 329
Aran's ether, 428
Arm, amputation of, 642
Arteries, amputation for lesion of, 562
influence of, on operation, 463
Arterial atheroma, 329
transfusion, 513
Arteriotomy, 509
Artery forceps, 574
Arthritism, 311
Artificial limbs, adaptation of, 606
respiration, 514 *et seq.*
in shock, 372
Ashhurst, amputations, 551
Asphyxia during anæsthesia, 412
Aspiration, 519
pneumatic, 595
Assistants during operations, 449
Astringents in erysipelas, 194
in inflammation, 157
Atheroma, arterial, 329
Aural symptoms in scurvy, 300
Auto-transfusion, 513
Aveling's method of transfusion, 510
Azoturia, 331

BANDAGE or bandages, 483
circular, 485
crossed or oblique of angle of jaw, 494
figure-of-eight, 491
of chest, anterior, 491
posterior, 491
of elbow, 491
of head and jaw, 493
handkerchief, 497
hardening, 498
for head, 493
many tailed, of Scultetus, 497
oblique, 485
plaster of Paris, 498
recurrent, of head, 494
of stumps, 495
roller, 483
sling or four tailed, 496
special, 485
spica, 488
of foot, 490
of groin, 489
of both groins, 490
of shoulder, 489
of thumb, 489
spiral, 485, 486
of chest, 488
of fingers, 486
of hand, or demi-gauntlet, 486
of penis, 488
reversed, 485
of lower extremity, 487
of upper extremity, 486.
despensory and compressor, of breast, 492
of both breasts, 493
T double, 496
T single, 496
use of, 483
V of head, 495
Velpeau's, 493
Bandaging, general rules for, 484
Basis-substance, vital processes in, 34
Béclard's amputation at hip-joint, 672
Belladonna in shock, 373
Benzene, 425
Bert on skin-grafting, 546
Bilious erysipelas, 186
Bisulphide of carbon, 433
Bites of serpents, delirium from, 384
and stings of insects, delirium from, 385
Bladder, care of, after operations, 454
Bleeding. See Venesection and Blood-letting.
from external jugular, 509
from internal saphena, 509
Blood, clot of, causing inflammation, 79
defect in quality of, causing inflammation, 70

Blood—
examination of, in pyæmia, 205
poison in, causing inflammation, 71
transfusion of, 509
direct, 510
Blood-letting, 505
in erysipelas, 193
in inflammation, 149
Blood-poisoning, 106
Bloodvessels, contractile elements of, 4
Bloody cupping, 506
Blunt knives in operations, 451
Bone forceps, 573
hypertrophy of, in stumps, 606
nippers, 573
suppurative inflammation in, 38
Bones, amputation for disease of, 564
of head, changes in, in rachitis, 260, 264
of lower extremity, changes in, in rachitis, 267
of trunk, changes in, in rachitis, 264, 265, 267
of upper extremity, changes in, in rachitis, 266
Bordeaux dressing of stumps, 598
Bowel affections, influence of, on operations, 467
Bowels, care of, after operations, 454
in scurvy, 292
Brain, effect of anæsthetics on, 407
BRINTON, operative surgery in general, 435
Bromide of ethyl, 428
Bryant on skin-grafting, 543
Burns, delirium from, 389
Bursæ in stumps, 606
BUTLIN, scrofula and tubercle, 231
Butylchloral hydrate, 430

CACHECTIC conditions causing erysipelas, 163
Cachexia, influence of, on operations, 468
scorbutic, 295
Calcareous degeneration, 62
Cancer, 313
Capillaries, contractility of, 5
Carbolic acid, 430
in erysipelas, 197
Carbon bisulphide, 433
Carbonic acid, 433
oxide, 433
tetrachloride, 426
Carden's amputation, 665
Cardism, 329
Caries in stumps, 605
Cartilage, suppurative inflammation in, 38
Cartilaginous changes in rachitis, 257

Catalepsy, delirium from, 392
Catarrhal inflammation, 132
Cathartics in inflammation, 157
Cautery, 504
galvanic, 523
Paquelin's, 505
Cell-nucleus, 42
Cells, apparent migration of, 34
fixed, new observations on, 51
of glands, contractility of, 9
Cellulitis, diffuse, of stumps, 602
Cerebral disease, effect of, in anæsthesia, 414
symptoms in scurvy, 299
Charpie, 479
Chemical irritants causing inflammation, 80
theory of pyæmia, 204
Chloral hydrate, 430
Chloride of amyl, 429
Chloroform, 426
administration of, 446
compared with ether, 442
first insensibility from, 431
history of, 405
mortality from, 422, 433
Chopart's amputation, 653
Chorea, delirium from, 385
Circular amputation, 579
Circulation, investigation of, in surgical diagnosis, 347
Climate causing inflammation, 73
Clinical thermometer, 348, 527
Clot of blood causing inflammation, 79
Coagulable lymph, 110
Cohnheim's theory of inflammation, 25
Cold, amputation for effects of, 562
a cause of erysipelas, 163
of inflammation, 74
in erysipelas, 194
in inflammation, 144
Colloid degeneration, 62
Color in surgical diagnosis, 345
Compresses, 480
Compression causing anæsthesia, 422
in inflammation, 147
Connective substance, comparison of, with supposed fibrillar substances, 43
Constitutional conditions, classification of, 307
effect of, in amputation, 622
in operations, 463
and injuries, reciprocal effects of, 307
influence of, 308
Contagion of erysipelas, 165
Contractile elements of bloodvessels, 4
Contractility of capillaries, 5, 9
Contused wounds, amputation for, 560
Contusion causing inflammation, 78
Coste on skin-grafting, 543
Cotton, 480
dressing for stumps, 598
Counter-irritation, 500
in inflammation, 153
Cranial bones, changes in, in rachitis, 260
Craniotabes, 261
symptoms of, 262
Croupous exudation, 109
Cupping, 505
Cutis, suppurative inflammation in, 38
transplantation of, 58. See also Skin-grafting.

DEFORMITIES, amputation for, 564
Deformity in rachitis, 260
Degeneration, amyloid, 62
calcareous, 62
colloid, 62
fatty, 61
of tissues, 61
DELAFIELD, pyæmia and allied conditions, 203
Delirium, anatomy of, 380
from bites of serpents, 384
and stings of insects, 385
from burns and scalds, 389
from catalpsy, 392
from chorea, 385
connection of, with insanity, 379
definition of, 379
from embolism, 382
from epilepsy, 392
from erysipelas, 391
from hectic fever, 392
from hemorrhage, 381
from hydrophobia, 385
from lacerated wounds, 387
from lesions of nerves of special sense, 383
after operations, 475
from pyæmia, phlebitis, etc., 393
from shock, 382
from surgical operations, 385
from surgical or traumatic fever, 385
from tetanus, 385
traumatic, 379
causes of, 381
treatment of, 394
Delirium tremens, 323, 394
causes of, 395
connection of, with mania-a-potu, 397
diagnosis of, 399
symptoms of, 397
treatment of, 401
Dentistry, anæsthesia in, 417
Dentition, effect of rachitis on, 268
Depressants in inflammation, 158
Destructive inflammation, 112, 115

Diabetes, alcoholic, 331
mellitus, 330
Diagnosis, surgical, 337
age in, 339
antecedent history in, 341
circulation in, 347
color in, 340
difficulties of, 338
digestive apparatus in, 352
duration of disease in, 343
expression of parts in, 343
genito-urinary system in, 354
habits in, 340
interrogation of internal organs in, 347
mensuration in, 346
mental and moral states in, 342
mobility in, 345, 351
movements in, 346
nervous system in, 350
occupation in, 340
pain, significance of, in, 351
personal examination in, 343
history in, 341
posture or attitude in, 343
residence in, 343
respiration in, 349
sex in, 339
smell in, 347
social condition in, 342
sound in, 346
special examination in, 343
temperature in, 345
thermometry in, 348
touch in, 345
translucency in, 345
weight in, 345
Diathesis, hemorrhagic, in operations, 470. See Hæmophilia.
Dichlorethane, 427
Diet in inflammation, 154
after operations, 453
Digestive apparatus in surgical diagnosis, 352
Digitalis in shock, 373
Dissecting forceps, 578
Dog, rabies in, 216
Donnelly on skin-grafting, 594
Drainage in inflammation, 152
after operations, 451
Dressing or dressings, choice of, 310
fixed, 498
after operations, 451
of stump, 593 *et seq.*
surgical, 479
Drunkenness, influence of, on operations, 458
Dry cupping, 505
Dupuytren's amputation at hip-joint, 674
at shoulder-joint, 645

EARTH dressing of stumps, 598
Effleurage, 525
Elbow, amputation at, 640
Electricity as an anæsthetic, 419
surgical uses of, 521
Electrolysis, 522
Elliptical amputation, 583
Emboli, mechanical and infectious, in pyæmia, 211
Embolism, delirium from, 382
fatty, 374
after operations, 475
in scurvy, 299
Emetics in erysipelas, 197
Endothelium, 55
Epididymitis in scrofula, 245
Epilepsy, 330
delirium from, 392
Epithelium, 55, 56
Erysipelas, 161
of air-passages, treatment of, 201
in amputations, 624
astringents in, 194
bilious, 186
blood-letting in, 193
carbolic acid in, 197
causes of, 162 *et seq.*
illustrated by history of epidemic outbreaks of disease, 168
cold in, 194
contagion of, 165
delirium from, 391
diagnosis of, 188
emetics in, 197
epidemic, connection of, with puerperal fever, 173
treatment of, 201
of face and scalp, 184
gangrenous, 183
history of, 161
incisions in, 196
iodine in, 195
iron, tincture of chloride of, in, 199
metastatic, 186
morbid anatomy of, 176
of new-born infants, 186
nitrate of silver in, 195
œdematous, 183
after operations, 477
phlegmonous, 182
prognosis of, 188
prophylaxis of, 190
punctures in, 196

Erysipelas—
purgatives in, 197
quinine in, 198
specific cause of, 167
stimulants in, 194
alcoholic, 198
of stump, 602
symptoms of, 177
synonyms of, 161
temperature in, 179
treatment of, 191
in infants and old persons, 201
internal, 197
surgical, 195
unity of various types of, 170
wandering, 178
Erysipelatous peritonitis, 187
Esmarch's apparatus, 569
Ethane, 424
Ether or ethers, 431
acetic, 432
administration of, 412, 443
Aran's, 428
compared with chloroform, 442
first insensibility from, 431, 443
formic, 432
history of, 404
hydrochloric, 427
hydriodic, 429
methylic, 431
mortality from, 423
nitric, 431
Ethereal salts, 431
Ethyl bromide, 428
Ethylene, 425
Examination of patient, 339
personal, in surgical diagnosis, 343
special, in surgical diagnosis, 343
Excitement, prostration with, 363
Expediency, operations of, 439
Expression of parts in surgical diagnosis, 343
Extravasations in scurvy, 297
Exudation, active and passive, 107
croupous, 109
inflammatory, 106
of plastic lymph, 108
Eyes, effect of anæsthetics on, 406

FARADIZATION, 525
Fatty degeneration, 61
embolism, 374
Fever, hectic, 129
delirium from, 392
infective and non-infective, 105
nature of, 102
in scurvy, 300
Fever—
surgical, traumatic, or inflammatory, 99, 455
causes of, 103
delirium from, 385
phenomena of, 100
treatment of, 456
Fibres, muscular, transversely striped, 44
smooth muscular, 47
Fibrillæ, nature of, 44, 51
theory of, 41
Figure-of-eight bandage, 491
Fingers, amputation of, 631 *et seq.*
First intention, healing by, 57
union by, 111
Fixed cells, supposed, new observations on, 51
dressings, 498
Flap amputation, 558, 584, 585
Fœtal rachitis, 253
Food, defects of, causing scurvy, 289
Foot, amputation of, 650
FORBES, hydrophobia and rabies, glanders, malignant pustule, 215
Forceps, artery, 573
bone, 573
dissecting, 578
Forearm, amputation of, 639
Foreign material in wound causing inflammation, 76
Formic ether, 432
Fractures, compound, amputation for, 560
delirium from, 387
Function, impaired or abolished, in inflammation, 99
Fungi, microscopic, causing inflammation, 85

GALVANIZATION, 525
Galvano-cautery, 523
Gangrene, 121, 137
amputation for, 563
after operations, 476
in stumps, 602
Gangrenous erysipelas, 183
Genito-urinary system in surgical diagnosis, 354
Germ theory of pyæmia, 205
Glanders, 225
diagnosis of, 227
prognosis of, 227
symptoms of, 225
in horse, 225
in man, 226
treatment of, 227
Glue and oxide of zinc bandage, 500
Gluttony, influence of, on operations, 459
Goltz's experiments on shock, 366

Gonorrhœa in scrofula, 245
Gout, 312
in scrofula, 246
Granulation, 112
healing by, 57
Gritti's amputation, 665
Gum and chalk bandage, 500
Gums in scurvy, 291, 296
Gunshot injuries, amputation for, 561
Guthrie's amputation at hip-joint, 672
Gutta-percha or rubber tissue, 482

HABITS of patient in operations, 458
in surgical diagnosis, 340
Hæmophilia, 318. See Hemorrhagic diathesis.
Hall's ready method of artificial respiration, 516
Hamilton on skin-grafting, 539
Hancock's amputation, 655
Hand, amputation of, 634
Handkerchief bandages, 497
Hardening bandages, 498
Head, bandages for, 493
Healing by first intention, 57
by granulation, 57
under scab, 111
Heart, effect of anæsthetics on, 408
influence of, on operations, 463
in scurvy, 291
Heat, amputation for effects of, 562
causing inflammation, 80
external, in shock, 371
in inflammation, 97, 146
Hectic fever, 129
delirium from, 392
Heitzmann's observations on rachitis, 256
Hemorrhage, 20
delirium from, 381
in hip-joint amputation, 674
in operations, 469, 472
in scurvy, 298
from stumps, 603
Hemorrhagic diathesis in operations, 470. See Hæmophilia.
Hepatism, 325, 326
Herpetism, 313
Hewitt's method of transfusion, 511
Hey's amputation, 652
Hip-joint, amputation at, 669
cases of, 678
hemorrhage in, 674
Hodgen on skin-grafting, 547
Hospital gangrene in stumps, 602
hygiene, influence of, on operations, 471
Howard's direct method of artificial respiration, 515
Hunt, traumatic delirium and delirium tremens, 379
Hunter, minor surgery, 479
Hydriodic ether, 429
Hydrocarbons and their derivatives as anæsthetics, 424
Hydrochloric ether, 427
Hydrophobia, 215
cause of, 215
delirium from, 385
diagnosis of, 220
incubation of, 217
morbid anatomy of, 219
prognosis of, 221
symptoms of, 218, 219
treatment of, 222
curative, 223
preventive, 222
Hygiene, hospital, influence of, on operations, 471
Hygienic surroundings, effect of, in amputation, 623
after operations, 454
Hyperæmia, 1
active, 2
causes of, 4
causing inflammation, 73
of irritation, 18
mechanical, 19
of paralysis, 18
passive, 3
Hyperplasia, 131
Hypertrophy, 131
Hypnotism, 421
Hypodermic injection, 518
Hysteria, 330

IMMOBILITY in inflammation, 142
Incisions in erysipelas, 196
in inflammation, 151
Incubation of hydrophobia, 217
Induration, 131
Infancy, operations in, 334
Infection of tubercle, 236
Infectious emboli in pyæmia, 211
Infective fever, 105
inflammation, 105
Inflammation, 65
absorption of poisons in, 92
anodynes in, 156
antiseptics in, 159
astringents in, 157
blood clot causing, 79
blood-letting in, 149
cardinal symptoms of, 23
catarrhal, 132

Inflammation—
causes of, 68, 71
exciting, 74
predisposing, 70
chemical irritants causing, 80
chronic, 130
climate causing, 73
cold, causing, 74
in, 144
compression in, 147
contusion causing, 78
counter-irritation in, 153
from defect in quality of blood, 70
defective or deranged nervous supply causing, 71
definitions of, 65
depressants in, 158
destructive, 112, 115
diet in, 154
drainage in, 152
foreign material in wounds causing, 76
habit of body in, 73
heat causing, 80
in, 97
and moisture in treatment of, 146
hyperæmia causing, 73
impaired or abolished function in, 99
incisions in, 151
infective and non-infective, 105
irrigation in, 145
irritation and injury causing, 68
laxatives in, 157
ligation of main artery in, 154
mechanical action causing, 80
violence causing, 78
mercury in, 156
microscopic fungi causing, 85
migration theory of, 25
nursing in, 154, 155
pain in, 98
parasites causing, 85
pathology of, 1
period of life in, 72
from poison in blood, 71
poisonous action of minerals causing, 81
of plants causing, 82
secretion of animals causing, 82
position in, 144
prevention of, 138, 140
putrid substances causing, 90
quinine in, 156
redness in, 96
rest and immobility in, 142
revulsion and counter-irritation in, 153
in the scrofulous, 133
stimulants in, 155
suppurative, in bone, 38
Inflammation, suppurative—
in cartilage, 38
in connective substances, 37
in cutis, 38
in tendon, 37
theory of, 25
swelling in, 97
symptoms of, 95
in the syphilitic, 134
terminations of, 135
theory of, 25
treatment of, 138
venom of serpents causing, 84
wounds causing, 75, 76
Inflammatory changes of tissues, 24
exudations, 106
fever, 99
Inflation, mouth to mouth, 514
Injections, hypodermic, 518
intravenous, anæsthesia from, 419
of milk, etc., 513
Injuries and constitutional conditions, reciprocal influence of, 308
Injury causing inflammation, 68
Inorganic substances as anæsthetics, 432
Insanity, 330
connection of delirium with, 379
Insensibility, first, from chloroform, 431
from ether, 431, 443
Instruments for operation, 450
Internal organs, interrogation of, in surgical diagnosis, 347
Intravenous injections, anæsthesia from, 419
of milk, etc., 513
Iodide of amyl, 429
Iodine in erysipelas, 195
Iodoform, 427
Iron, tincture of chloride of, in erysipelas, 199
Irrigation in inflammation, 145
Irritation causing inflammation, 68
hyperæmia of, 18
Ischæmia, 3
causes of, 4
Issues, 502

JOHNSTON, plastic surgery, 531
Joints, amputation for disease of, 564
in scurvy, 291
Jugular, external, bleeding from, 509

KERATITIS, suppurative, 28
Ketones, 432
Kidneys in scurvy, 292, 299
Kneading, 525
Knee, amputation at, 663, 665

Knee-joint, amputation at, 663
Knives, amputating, 570
blunt, in operations, 451

LACERATED wounds, amputation for, 560
Langenbeck's method of amputating, 587
Larrey's amputation at hip-joint, 674
at shoulder-joint, 644
Laryngismus stridulus, connection of, with rachitis, 263
Laxatives in inflammation, 157
Leanness, influence of, on operations, 458
Leech, artificial or mechanical, 508
Leeching, 507
Lee's amputation, 662
Le Fort's amputation, 659
Leg, amputation of, 660
Leucocythæmia, 318
Lewisson's experiments on shock, 369
Ligation of main artery in inflammation, 154
Ligatures in amputations, 575
invention of, 554
Limb, avulsion of, amputation for, 559
Limbs, artificial, adaptation of, 606
pains in, in scurvy, 296
Lint, 479
Liquor puris, 116
Lisfranc's amputation, 652
at hip-joint, 674
at shoulder-joint, 646
Lister's method of amputating, 588
Liston's amputation at hip-joint, 672
Liver, influence of, on operations, 467
in scurvy, 292, 300
Local anæsthesia, 418, 447
Locality, influence of, on operations, 463
Locomotor ataxia and various neuroses, 329
Lower extremity, special amputations of, 649 *et seq.*
Lungs, influence of, on operations, 464
in scurvy, 292
Luxations, compound, amputation for, 560
LYMAN, anæsthetics and anæsthesia, 403
Lymph, coagulable, 110
plastic, 110
exudation of, 108

MACKINTOSH, 483
Malaria, 321
Malgaigne's method of amputating, 584
Malignant pustule, 228
pathology of, 229
symptoms of, 228
treatment of, 229
Mania-a-potu, 397
MANSELL-MOULLIN, shock, 357
Martin on skin grafting, 546
Massage, 525
Maxillæ, changes in, in rachitis, 264
Mechanical emboli in pyæmia, 211
hyperæmia, 19
Mèche, 481
Mensuration in surgical diagnosis, 346
Mental emotion, a cause of shock, 358
and moral states in surgical diagnosis, 342
powers, impairment of, in scurvy, 296
preoccupation and expectation, a cause of shock, 359
Mercury in inflammation, 156
Metacarpus, amputations of, 635, 636
Metastatic erysipelas, 186
Metatarsus, amputations of, 650 *et seq.*
Methane, 424
Methylal, 431
Methylene bichloride, 426
Methylic chloride, 426
ether, 431
iodide, 427
Migration, apparent, of cells, 34
Milk, intravenous injection of, 513
Minerals, poisonous action of, causing inflammation, 81
Minor surgery, 479
Mixtures, anæsthetic, 420
Mobility in surgical diagnosis, 345, 351
Modified circular amputation, 582
Moisture in inflammation, 146
Monochlorotetrane, 429
Morbid growths, amputation for, 564
Morphinism, 324
Mortality and causes of death after amputations, 610
from artificial anæsthesia, 422
from chloroform, 422, 433
from ether, 423
from nitrous oxide, 423
Mortification, amputation for, 562
Motion, passive and active, 526
Mouth in scurvy, 291
Movements in surgical diagnosis, 346
Moxa, 503
Mucous surfaces, formation of pus on, 119
Muller's experiments on shock, 367
Muscle-beating, 526
Muscles, retraction of, in stumps, 602
spasm of, in stumps, 602
Muscular movements, effects of anæsthetics on, 407

NECESSITY, operations of, 439
Necrosis, connective tissue, with purulent infiltration, 127

Necrosis—
in stumps, 605
Needles, 578
Nephrism, 327
Nerves, delirium from lesion of, 383
vaso-motor, 11
Nervous centres, toxic effect of anæsthetics on, 414
supply, defective or deranged, causing inflammation, 71
system, central, white and gray matter of, 47
influence of, on operations, 459
in scurvy, 291
in surgical diagnosis, 350
Neuromata in stumps, 604
New formations, non-inflammatory, 60
Nitrate of silver in erysipelas, 195
Nitric ether, 431
Nitrite of amyl, 429
Nitrogen, 432
Nitrous oxide, 432
history of, 404
mortality from, 423
Non-infective fever, 105
inflammation, 105
Non-inflammatory new formations, 60
Nursing in inflammation, 154, 155
Nutrition, disturbances of, 1
paths for, 33

OAKUM, 480
Obesity, influence of, on operations, 457
Obstetrics, anæsthesia in, 416
Occlusion, pneumatic, 595
Occupation in surgical diagnosis, 340
Octane, 425
Œdema, 107
in scurvy, 297
spaces for, 33
Œdematous erysipelas, 183
Oiled silk, 482
Old age, operations in, 335
Ollier on skin-grafting, 544
Open method of dressing stumps, 597
Operation or Operations, 438
after-dressing of, 451
anæsthesia in, 441
assistants during, 449
care of bladder after, 454
of bowels after, 454
causes of death after, 472
choice of, 310
condition of part influencing, 470
patient after, 470
before, 457
Operation—
conditions determining results of, 456 *et seq.*
diet after, 453
drainage after, 451
hemorrhage in, 469, 472
hemorrhagic diathesis in, 470
hygienic surroundings after, 454
immediate dangers of, 449
in infancy, 334
instruments for, 450
mode of conducting, 448
of necessity and expediency, 439
obesity in, 457
in old age, 335
posture of patient for, 449
preliminary treatment before, 441
preparation for, 438
of patient for, 440
rest before, 440
rules for, during pregnancy, 334
shock in, 469, 473
time of, 310, 439
treatment of patient after, 452
use of blunt knives in, 451
Operative methods in amputation, 579
surgery in general, 435
Ophthalmic symptoms in scurvy, 300
Opium in shock, 372
Osseous changes in rachitis, 258
Osteitis in stumps, 604
Osteomyelitis in stumps, 604
Oval amputation, 584

PAIN, a cause of shock, 359
in inflammation, 98
significance of, in surgical diagnosis, 351
Pancreas in scurvy, 292
Paper-lint, 480
Paquelin's cautery, 505
Paraffin bandage, 500
Paralysis, hyperæmia of, 18
Parasites causing inflammation, 85
Passive motion, 526
Pathology of inflammation, 1
Pellets and bullets, 481
Pelvis, changes in bones of, in rachitis, 267
Pentane, 425
Perchloride-of-iron dressing for stumps, 597
Percussion, 526
Periosteum in scurvy, 291
Periostitis in stumps, 604
Peritonitis, erysipelatous, 187
Personal history in surgical diagnosis, 341
Pétrissage, 525
Phlebitis, delirium from, 393

Phlegmonous erysipelas, 182
Phosphaturia, 331
Physiology of anæsthesia, 409
Pirogoff's amputation, 658
Plants, poisonous action of, causing inflammation, 82
Plastic lymph, 110
exudation of, 108
operations, classification of, 536
general principles of, 535
rules for, 537
surgery, 531
history of, 532
lesions remediable by, 533
Pledget, 481
Plethora in operations, 458
Pliers, cutting, 573
Pneumatic aspiration, 595
occlusion, 595
Pollock on skin-grafting, 544
Polyuria, 331
Poncet on skin-grafting, 543
Position in inflammation, 144
Posture or attitude in surgical diagnosis, 343
of patient for operations, 449
Pregnancy, 332
operations in, 334
Prevention of inflammation, 138, 140
of shock, 371
Prolonged suppuration, 213
Prostration with excitement, 363
Protective, 482
Prothetic apparatus for lower extremity, 608
for upper extremity, 607
Puncturation, 505
Punctures in erysipelas, 195
Purgatives in erysipelas, 197
Purulent infiltration with connective tissue necrosis, 127
Pus absorption, theory of, in pyæmia, 204
anatomical characteristics of, 116
formation of, 112
phenomena attending, 119
on serous and mucous surfaces, 119
liquid portion of, 116
physical qualities of, 114
poisonous qualities of, 123
significance of odors from, 122
sources of, 116
substances mistaken for, 126
uses of, 124
varieties of, 125
waste of tissue from, 124
Pustule, malignant, 228, 229
Putrid substances causing inflammation, 90
Pyæmia, 106
and allied conditions, 203
Pyæmia—
in amputation, 624
chemical theory of, 204
delirium from, 393
examination of blood and tissues in, 205
experiments on animals in, 206
germ theory of, 205
mechanical and infectious emboli in, 211
nature of, 204
nomenclature of, 203
after operations, 477
spontaneous, 214
symptoms and lesions of, 207
theory of pus absortion in, 204
treatment of, 211
Pyrrol, 429

QUININE in erysipelas, 198
in inflammation, 156

RABIES, 215
in dog, 216
Race, influence of, on operations, 461
Rachitis, 251
age of occurrence of, 252
anatomical characters of, 257
artificial production of, 255
cartilaginous changes in, 257
causes of, 254
changes in bones of lower extremity in, 267
of pelvis in, 267
of upper extremity in, 266
in cranial bones in, 260
in maxillæ in, 264
in ribs in, 265
in soft parts in, 269
in vertebræ in, 264
complications of, 271
connection of, with laryngismus stridulus, 263
craniotabes in, 261
deformity in, stage of, 260
diagnosis of, 272
diet in, 274
effect of, on dentition, 268
fœtal, 253
frequency of, 251
Heitzmann's observations on, 256
from improper food, 254
inheritance in, 254
medicines in, 275
osseous changes in, 258

Rachitis—
pathology of, 259
prognosis of, 273
proliferation and altered nutrition in, stage of, 257
reconstruction in, stage of, 270
sequelæ of, 271
symptoms of, 270
treatment of, 274
Ravaton's method of amputating, 585
Reaction from shock, 369
Redness in inflammation, 96
Reflex action, effect of anæsthetics on, 408
Regeneration, 59
Resolution, 136
Respiration, artificial, 514 *et seq.*
in shock, 372
effect of anæsthetics on, 408
rapid, as an anæsthetic, 419
in surgical diagnosis, 349
Rest before operations, 440
in inflammation, 142
Retractors, 481, 577
Revaccination, 517
Reverdin on skin-grafting, 539
Revulsion, 500
in inflammation, 153
Rheumatism, 311
Ribs, changes in, in rachitis, 265
Richardson's bellows, 515
Rickets, 251. See Rachitis.
Roller bandages, 483
Roussel's method of transfusion, 511
Roux's amputation, 658
Rubefacients, 501

SALTS, ethereal, 431
Saphena, internal, bleeding from, 509
Saturnism, 324
Saws, amputating, 571
Scab, healing under, 111
Scalds, delirium from, 389
Scarification, 505
Scissors, 579
Scoutetten's method of amputating, 584
Scrofula, 240, 315
cases illustrative of, 240
causes and course of, 246
diagnosis of, 242
in gonorrhœa and epididymitis, 245
in gout, 246
modifications produced in other diseases by, 245
morbid anatomy of, 242
nature of, 241
prognosis of, 246
Scrofula—
relation of, to tubercle, 244
in syphilis, 245
tissues and organs affected by, 243
treatment of, 247
constitutional, 247
local, 248
Scrofulous, inflammation in the, 133
Scultetus, bandage of, 497
Scurvy, 277, 317
cerebral symptoms in, 299
from defects in food, 289
diagnosis of, 301
effect of age in, 285
of depressing emotions in, 286
of food supply in, 288
of foul air in, 287
of impure water in, 287
of individual peculiarities in, 287
of low temperature in, 286
of sex in, 285
embolism, etc., in, 299
etiology of, 285
extravasations of blood and œdema in, 297
fever in, 300
geographical limitations of, 285
heart in, 291
hemorrhages in, 298
history of, 277
impairment of mental powers in, 296
joints in, 291
kidneys in, 292, 299
liver, spleen, and pancreas in, 292, 300
lungs in, 292
morbid anatomy of, 290
mouth, gums, etc., in, 291, 296
nervous system in, 291
ophthalmic and aural symptoms in, 300
pains in limbs in, 296
pathology of, 293
periosteum in, 291
prognosis of, 301
prophylaxis of, 302
rigor mortis in, 290
scorbutic cachexia in, 295
serous effusions in, 298
membranes in, 291
skin and connective tissue in, 290
stomach and bowels in, 292
symptoms of, 295
synonyms of, 277
treatment of, 302
curative, 304
urinary symptoms in, 299
from use of salted meats, 288
Seasons, influence of, on operations, 461
Secondary adhesion, union by, 114

Secretions, effect of anæsthetics on, 408
poisonous, of animals, causing inflammation, 82
Sédillot's amputation of leg, 661
method of amputating, 586
Sensibility, general, effect of anæsthetics on, 406
Septicæmia, 106
after operations, 477
Serous effusions in scurvy, 298
membranes in scurvy, 291
surfaces, formation of pus on, 119
Serpent-bites, delirium from, 384
Serpents, venom of, causing inflammation, 84
Seton, 503
Sewer-gas causing erysipelas, 164
Sex, effect of, in amputation, 622
in anæsthesia, 414
in shock, 359
influence of, on operations, 460
in surgical diagnosis, 339
Sheppard, table of hip-joint amputations, 678
Shock, 357
ammonia in, 373
anæsthetics in, 374
artificial respiration in, 372
cases attended by, 359
causes of, 357
delirium from, 382
external heat in, 371
Goltz's experiments on, 366
Lewisson's experiments on, 369
from mental emotion, 358
preoccupation and expectation, 359
in operations, 469, 473
opium in, 372
from pain, 359
pathology of, 365
prevention of, 371
prognosis of, 369
reaction from, 369
stimulants in, 372
strychnia, belladonna, and digitalis in, 373
symptoms of, 362
Tappeiner's and Muller's experiments on, 367
transfusion in, 372
treatment of, 371
venesection in, 373
Shoulder, amputation above, 647
at, 643
Silicate-of-potassium bandage, 500
Simple dressing of stumps, 599
Simultaneous amputations, 590, 592
Skin-grafting, 538 *et seq.*
in scurvy, 290
Sloughing after operations. 476
of stumps, 602
Smell in surgical diagnosis, 347
Smith, rachitis or rickets, 251
Social condition in surgical diagnosis, 342
Sound in surgical diagnosis, 346
Special amputations of lower extremity, 649 *et seq.*
of upper extremity, 631 *et seq.*
Sphygmograph, use of, 529
Spica bandages, 488
Spinal cord, suppuration of, 48
disease, effect of, in anæsthesia, 414
Spiral bandages, 485
Spleen in scurvy, 292, 300
Spontaneous pyæmia, 214
Starch bandage, 500
Stillé, erysipelas, 161
Stimulants in erysipelas, 194
alcoholic, 198
in inflammation, 155
in shock, 372
Stokes's amputation, 666
Stomach in scurvy, 292
Stricker, pathology of inflammation, 1
Stroking, 525
Strychnia in shock, 373
Stumps, adventitious bursæ in, 606
after-treatment of, 600
aneurism of, 604
bandage for, 495
caries in, 605
contraction of tendons in. 603
diseases of, 601
dressing of, 593 *et seq.*
erysipelas and diffuse cellulitis of, 602
hemorrhage from, 603
hospital gangrene in, 602
hypertrophy of bone in, 606
necrosis in, 605
neuromata of, 604
periostitis, osteitis and osteo-myelitis in, 604
retraction of muscles in, 602
sloughing of, 602
spasm of muscles in, 602
structure of, 601
Subastragaloid amputation, 654
Substances, inorganic, as anæsthetics, 432
Suppuration, 112
injurious consequences of, 126
prolonged, 213
significance of, 122
of spinal cord, 48
Suppurative inflammation in connective substances, 37
keratitis, 28

Surface thermometer, 528
Surgeon, demeanor of, 437
  qualifications of, 435
    personal, 435
Surgery, anæsthesia in, 416
  diagnostic power in, 438
  knowledge of anatomy in, 436
  minor, 479
  plastic, 531. See Plastic Surgery.
  operative, 435. See Operation.
  selection of cases in, 437
  use of thermometer in, 527 *et seq.*
Surgical diagnosis, principles of, 337. See Diagnosis.
  dressings, 479
  fever, 455
  operations, delirium from, 385
  or traumatic fever, delirium from, 385
  uses of electricity, 521
Sutures in amputation, 577
Swelling in inflammation, 97
Sylvester's method of artificial respiration, 515
Syme's amputation, 656
Synchronous amputations, 590, 592
Syncope during anæsthesia, 412
Syphilis, 319
  scrofula in, 245
Syphilitic, inflammation in the, 134

TAPPEINER'S experiments on shock, 367
Tapotement, 526
Tarsus, amputations through, 653
Teale's method of amputating, 587
Temperament, effect of, in anæsthesia, 414
  influence of, on operations, 461
Temperature, effect of anæsthesia on, 408
  in erysipelas, 179
  in surgical diagnosis, 345
Tenacula, 574
Tendon, suppurative inflammation in, 37
Tendons, contraction of, in stumps, 603
Tent, 481
Tetanus, amputation for, 564
  delirium from, 385
  after operations, 476
Tetrane, 424
Thermometer in surgery, 527 *et seq.*
Thermometry in surgical diagnosis, 348
Thigh, amputation of, 667 *et seq.*
Thoracic disease, effect of, in anæsthesia, 414
Thrombosis, delirium from, 382
  after operations, 475
Thumb, amputation of, 634
Tissue, apparent migration of cells in midst of, 34
Tissue—
  inflammatory changes of, 24
  metamorphosis, doctrine of, 27
  production, 136
Tissues, degeneration of, 61
  examination of, in pyæmia, 205
Toes, amputations of, 649
Touch in surgical diagnosis, 345
Tourniquet in amputation, 565
  invention of, 555
Tow, 479
Toxic effect of anæsthetics on nervous centres, 414
Transfusion, arterial, 513
  of blood, 509 *et seq.*
  indirect, 511
  in shock, 372
Translucency in surgical diagnosis, 345
Transplantation of cutis, 58. See Skin-grafting.
Traumatic delirium, 379
    diagnosis of, 393
    treatment of, 394
  fever, 99, 455
Trichlorethane, 428
Tripier's amputation, 655
Trousseau, treatment of erysipelas, 192
Tubercle, 231
  analysis of cases of, 234
  cases illustrative of, 231
  infection of, 236
  morbid anatomy of, 234
  nature of, 237
  origin and natural history of, 235
  pathology of, 238
  treatment of, 238
Tuberculosis, 316
Turpentine, 425

ULCERATION, 120
Union by first intention, 111
  by secondary adhesion, 114
Upper extremity, amputations of, 631
Urinary organs, influence of, on operations, 465
  symptoms in scurvy, 299

VACCINATION, 516
VAN BUREN, inflammation, 65
Vaso-motor nerves, 11
Velpeau's bandage, 493
Venesection, 508
  in shock, 373
Veins, air in, after operations, 476
Vermale's method of amputating, 585
VERNEUIL, reciprocal effects of constitutional conditions and injuries, 307

Vertebræ, changes in, in rachitis, 264
Vesicants, 501
Virchow's theory of inflammation, 25
Visceral affections, influence of, on operations, 463
Vital processes in basis substance, 34
Volition, effect of anæsthetics on, 407

WADDING dressing of stumps, 598
Wales, scurvy, 277
Wandering erysipelas, 178
Water dressing of stumps, 593
proof paper, 482
Waxed paper, 482
Weather, influence of, on operations, 461
Weight in surgical diagnosis, 345
Wet or bloody cupping, 506
Wood spirit, 430
Wounds causing inflammation, 75, 76
lacerated, delirium from, 387
Wrist, amputation at, 637

END OF VOL. I.